BRITISH SULPHUR CORPORATION LTD

QUARTERLY BULLETIN

DECEMBER, 1956 - - No. 15

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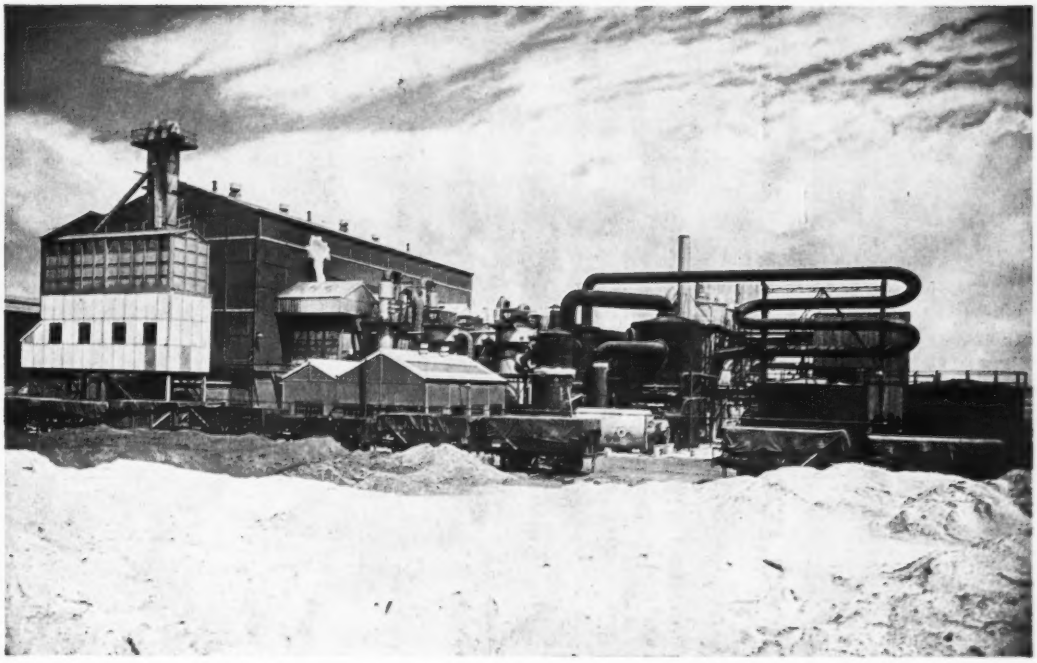

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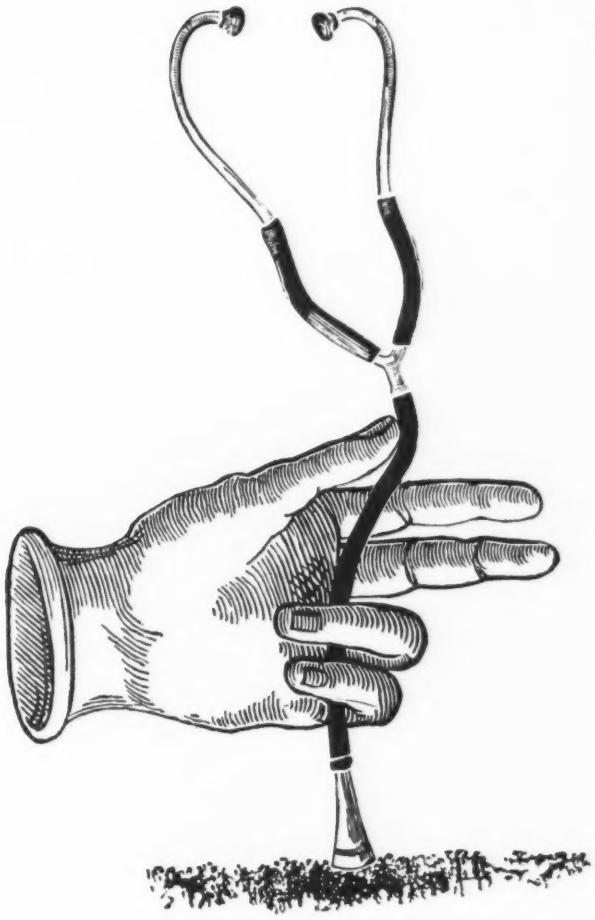

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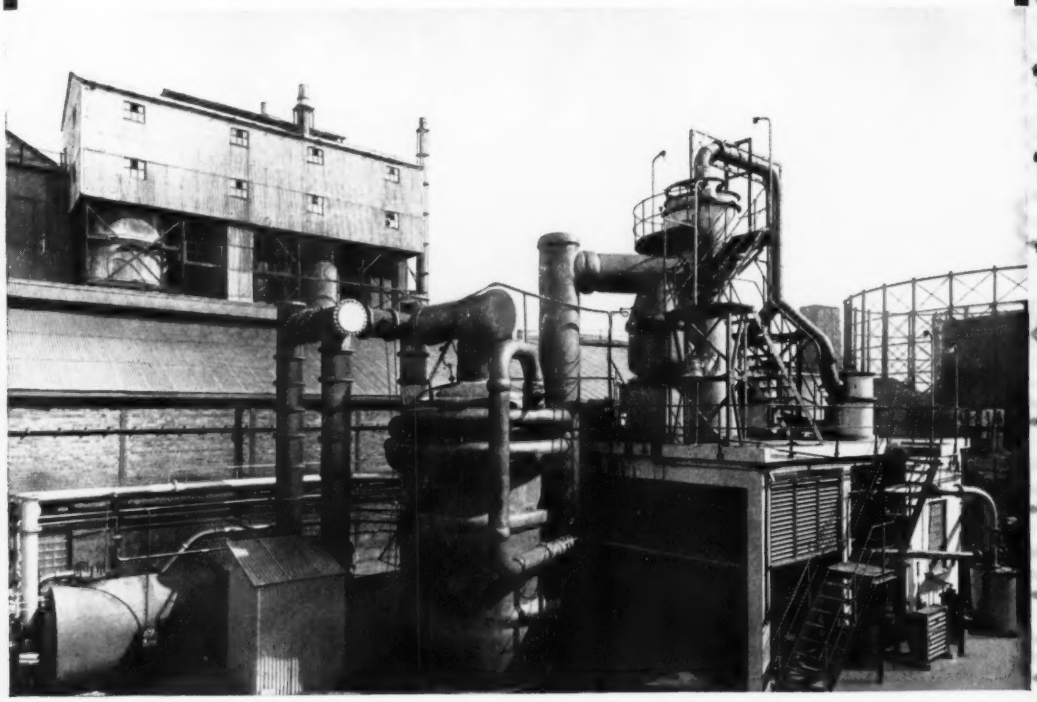

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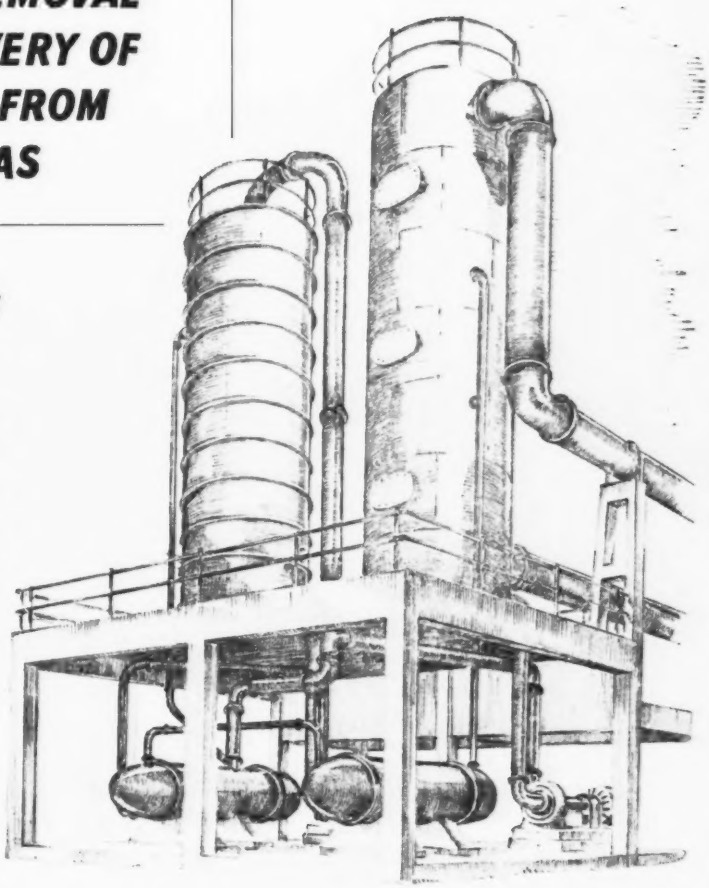

NOTE THESE ADVANTAGES

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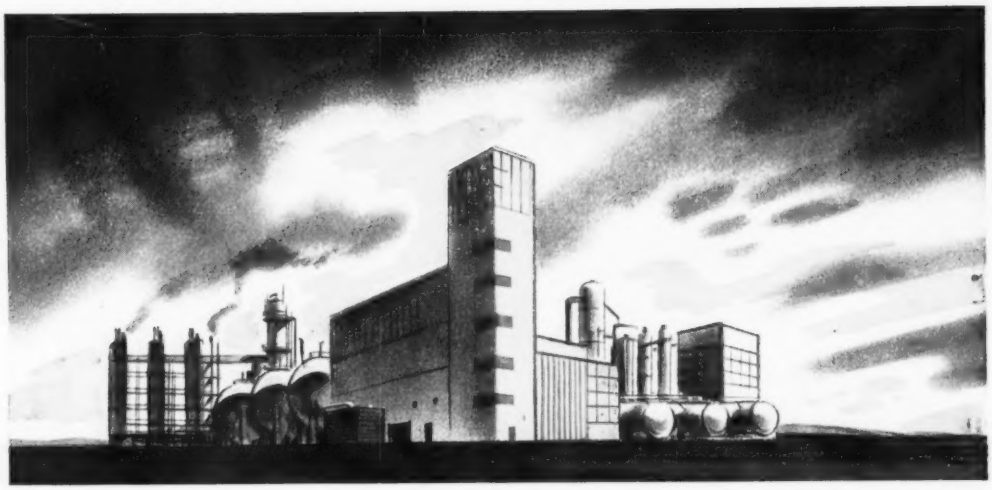

Electric Bond and Share Company enters Chemical Engineering

The entry of the powerful Electric Bond and Share Company of New York into the field of chemical engineering marks an important development in the industry. A few months ago the Company bought the Chemical Construction Corporation, New York—a subsidiary of the American Cyanamid Company. More recently, it formed a new company—Chemical Construction (Great Britain) Ltd., which took over the Chemical Engineering Division of Cyanamid Products Ltd., London. These developments mean that American capital and technical knowledge can be harnessed to British chemical engineering and its export drive. The link-up of Electric Bond and Share Company—with its 50-year history and world-wide contributions to public utilities and industrial engineering with the long specialised experience in chemical engineering of the former Cyanamid subsidiaries, foreshadows a new potential in the chemical and petrochemical industries. Close co-operation within the new Group is planned for the design and erection of plant for producing nitric and sulphuric acids, synthetic fertilisers and numerous other materials in the United Kingdom and overseas countries where dollar conservation on such construction is all-important.

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DECEMBER 1956

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Review

TRENDS in European Sulphur Consumption during the five years up to 1955, provide valuable but not decisive pointers, mainly due to the lingering influence of events during the sulphur crisis. Sulphur usage which, in line with total industrial, rather than chemical, production had expanded at an average annual rate of 6½%, totalled 5½ million tons in 1955 and was 1½ million tons greater than in 1949/50; it was divided between brimstone 21%, pyrites 59% and other sulphurous raw materials 19%. In the 18 countries under review non-acid uses—notably pulp, rayon and agriculture—accounting for 27% of total consumption were met predominantly (50%) in the form of brimstone whereas the bulk (67%) of sulphur used in acid manufacture was in the form of pyrites.

For the following five-year period it is expected that average expansion will be slower, only 3-4% per annum, representing a gradual increase of sulphur usage to 6½-6¾ million tons in 1960. Of the additional needs of 1-1¼ million tons sulphur in various forms, it may be expected that about one-third will be met by indigenous supplies as a matter of course. Sulphur recovery, especially the anticipated output from sour natural gas at Lacq, may be expected to limit actual import requirements to ½ million tons brimstone or pyrites.

Brimstone, already in a position of preference in many markets, may be expected to seek a greater share owing to the heavy pressure of abundant supplies. To meet this challenge pyrites, which are still the more favourable source of sulphur in many European markets will have to pursue a flexible price policy. As long as the impact of transatlantic coal trade unsettles both sulphur and pyrites freights, neither source of supply is likely to gain a decisive position of advantage.

In the **United States** during the third quarter, Frasch and recovered sulphur productions were both at record levels totalling 1,871,098 tons. At nearly 1¾ million tons—17¼% more than in the third quarter of 1955—Frasch sulphur output appears to have been determined not by the consumption pattern, but rather by producers' policies relating to desirable production rates and stock levels. Domestic consumption and export shipments were at record levels for the third quarter. The steel strike in July failed to affect sulphur consumption significantly; sulphuric acid not used for pickling or by-product ammonium sulphate manufacture was readily taken up elsewhere notably by wet phosphoric acid and superphosphate makers and, over three months, acid output of 3.58 million tons was fractionally higher than in the previous year. Rising imports of Mexican sulphur restricted Frasch sulphur outlets and notwithstanding the satisfactory export tonnage of 463,000 tons, Frasch sulphur stocks rose 350,000 tons, bringing the total stocks to 3.8 million tons.

In his traditional end-of-year **Review of the U.S. Sulphur Industry** Mr. Langbourne M. Williams, President of the Freeport Sulphur Company, summed up the achievements of the U.S. sulphur industry in its third consecutive record year. Output of sulphur in all forms is estimated at 7,875,000 tons; Frasch sulphur production from 13 domes in Texas and Louisiana, of which one, Freeport's Nash dome, was closed in November, totalled 6,450,000 tons or about 700,000 tons more than in 1955. During the year developments of two new domes and further installation of recovery plants were announced and 1956 also saw five new sulphur recovery plants at oil refineries, four at natural gas cleaning plants and expansion of six established installations. Reviewing the U.S. pattern of consumption, Mr. Williams could discover no change other than a welcome expansion of demand.

By-product sulphuric acid production by the **Bunker Hill Company,** the oldest lead/zinc ore mining company in the Western U.S.A., is based on a Leonard-Monsanto contact acid plant rated at 300 tons per day (100% H_2SO_4). Output may be augmented up to 900 tons per day by making use of sulphur in additional waste gases from zinc and lead smelting operations, provided that an adequate outlet for acid becomes available.

Sulphur Recovery at the Marcus Hook Oil Refinery raises daily output by the Sinclair Refining Co. to 100 tons high purity sulphur.

The end of the second year of effective operation of the **Sulphur Industry of Mexico** records a series of outstanding achievements.

Pan American Sulphur Company, announced President H. C. Webb, produced the one-millionth ton of sulphur on 10th December and, with an anticipated output of 600,000 tons in 1956, is the third largest Frasch sulphur producer in the world. At the La Salinas dome of the Gulf Sulphur Corporation satisfactory operation since May and the company's growing order book are reflected by the increase of output from the 400 tons per day level. New loading and dock facilities built at Coatzacoalcos by the parent Hudson Engineering Company were taken into service in December and a filtering plant is under construction. Texas Gulf Sulphur Company has deferred the start of operations at the Santa Anita dome, possibly pending the decision on the construction of a filtering plant and whether to distribute output from Mexico or from the Company's main storage at Galveston. Reflecting the vigorous policy of the Texas International Sulphur Company is an 18-months programme covering six known domes within the concession area and the preparation of plans for the construction of a 1,000 tons per day Frasch plant at the Texistipec dome.

In **Italy** a growing volume of low-grade sulphur ore is taken up by sulphuric acid manufacture. Refined sulphur output during the three months period ending 30th November, of 60,681 metric tons, was 8½% less than in 1955 and being substantially exceeded by domestic and export shipments permitted a reduction of the stockpile to 285,753 tons.

In the **United Kingdom** consumption of sulphur in all forms in the third quarter totalled 210,000 tons, 3½% more than in the corresponding period of 1955. The reduction to 26,100 tons of regular sulphur use reflected the difficulties of the car and rayon industries. Sulphuric acid output of 515,632 tons (100% H_2SO_4) was 5½% greater than in the third quarter of 1955 and consumption, mainly due to greater demand for titanium dioxide, detergent and superphosphate manufacture, also advanced. Acid production for the first nine months was at an annual rate of 2¼ million tons, 9% greater than last year notwithstanding the near stagnation of the level of industrial production. The Suez crisis is expected to have little if any effect on the rate of sulphur and pyrites imports in the fourth quarter. The effect of petrol rationing on the free movement of acid by road, the prevalent means of distribution, is, however, serious and cannot fail to curtail the activities of the sulphur industry which normally at this time of year are at a high level.

At the **Avenue Carbonisation and Chemical Plant** of East Midland Division of the National Coal Board, one of the most up-to-date installations in the world, sulphur recovery from coal gas in the form of spent ferric oxide is integrated with sulphuric acid manufacture by the Kachkaroff system. The installation is said to be a prototype for the United Kingdom coal and gas industries.

The **Coppée Process for the Extraction and Recovery of Sulphur from Coal Gas** at coke ovens and town gas works is based on the use of ammonia as a washing medium. The economics of the process and plant which has been developed from a former I.G. Farbenindustrie patent by the Coppée Company (Great Britain) Ltd., point to a wide range of advantageous applications. No less than other wet purification processes it represents a challenge to the U.K. carbonisation industry.

A **Fluidised Bed Process for Carbon Disulphide Manufacture** is reported to have been developed and put into operation in East Germany. Replacing the conventional retorts, the inherent thermodynamic limitations of which have added to CS_2 and thus rayon manufacturing costs, the new process is said to offer greater efficiency and on account of its ability to use cheaper carbon than charcoal, considerable savings in operation.

World Prices of sulphur have remained stable at $28 per ton for U.S. bright sulphur to all destinations while Mexican prices continue to range from $24-26.50 per ton. European pyrites prices are reported to remain unchanged at £4 10s.-£5 per metric ton. The exorbitant rise in sea freights in recent weeks has strictly limited sulphur and pyrites charters which at prevailing freight rates raised the landed cost of brimstone by up ot 25%.

World Supplies of brimstone are abundant following the peak output in Mexico and U.S.A. which have resulted in producers' stocks being increased by about 1 million tons. Planned dome developments and world-wide expansion of sulphur recovery facilities which is being stimulated by the high landed cost of sea-borne sulphur supplies promise the continuance of a competitive world market.

TRENDS IN EUROPEAN SULPHUR CONSUMPTION

General

THE brief period of post-war reconstruction and re-adjustment in the sulphur industries of Free Europe, in the course of which they were resuming their normal development under the influence of ready supplies of the various raw materials, came to a close towards the end of 1949. By that time, with the rehabilitation of the pyrites residues' treatment plants in Germany—achieved largely as the result of the intervention of the United Kingdom Spanish pyrites property owners with the Allied Occupation Authorities and the potential suppliers of residues—the linchpin of traditional pyrites usage on the Continent had been restored. Nevertheless U.S. Frasch sulphur had so improved its competitive position in relation to pyrites, which were being adversely affected by the rising costs of production, transportation and handling, that the trend of sulphur usage in Western Europe—especially in the United Kingdom—strongly favoured brimstone. This trend failed to establish itself because a world-wide crisis of elemental sulphur supply, resulting in the International control of its distribution and use, marked the beginning of a new period, which may be said to have lasted until 1955. In this time European sulphur consumption in all forms expanded rapidly and in 1955 amounted to 5½ million tons which was 1½ million tons sulphur more than in 1949.

The imposition of elemental sulphur rationing, however, resulted in the emergence of an unnatural pattern of consumption in the majority of European countries as, in the absence of a balanced mechanism of supply and demand, expansion plans of many acid industries deliberately avoided dependence on elemental sulphur, often in defiance of the economic disadvantages. Although the actual limitation on elemental sulphur supplies was reasonably quickly remedied, the effects of "the crisis" persisted mainly on account of the introduction of plant based on alternative raw materials but also as the result of widespread apprehension of a possible recurrence.

The assurance of adequate future supplies of elemental sulphur became apparent about two years ago with the start of Freeport Sulphur Company's Garden Island Bay dome and developments in other sources of elemental sulphur supply notably Mexico. Since then an increasing number of individual users have exercised their freedom of choice, and where economically advantageous have returned to the use of elemental sulphur. This development of the natural patterns of consumption includes, in most European countries, the use of sulphur or sulphuric acid resulting from recovery processes, many of which owe their growth to the stimulus derived from the period of shortage.

Consumption

Between 1949*, the last normal year prior to the sulphur crisis, and 1955 the total sulphur consumption in Western Europe rose from approximately 4 million to 5½ million tons. This increase corresponds to the rate of ex-

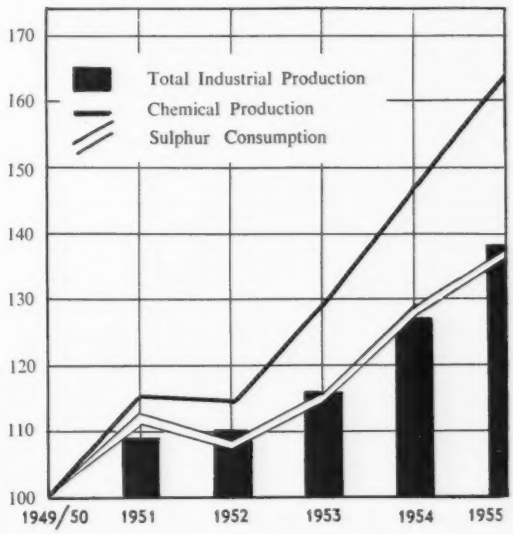


Fig. 1. Indices of Industrial and Chemical Production and Sulphur Consumption in O.E.E.C. Countries (1950 = 100).

* Year ending 30th June, 1950.

pansion of total industrial production, whereas chemical production, mainly on account of the spectacular development in the organic, notably the petrochemical, sector of the industry, rose faster. In Fig. 1 particulars shewn in the recently published Annual Report of the Chemicals Products Committee of O.E.E.C. of changes in the combined indices for industrial and chemical production in O.E.E.C. countries have been combined with a commensurate index of sulphur usage.

Sulphur needs for sulphuric acid manufacture, fluctuating between 70%-75% of total consumption, have risen 1.2 million tons (43%) whereas non-acid uses increased about 260,000 tons (21%). In the 5 year-period under review acid production has grown more rapidly in Western Europe than in U.S.A. although in the last year, when expansion was comparable at about 6%, the rate of growth in Western Europe had slowed down. It is not thought that this slowing down was connected with the coincident check to the rate of growth of pyrites use, which may be solely attributed to greater availability and economic advantages in the use of elemental sulphur. In spite of its notable recovery, acid sulphur use in 1955 was still 54,000 tons (11%) lower than in 1949/50. Pyrites consumption for acid manufacture rose 50% while the use of other sources of supply, notably sulphur in smelter exit gases, coal gases and anhydrite, expanded by 67%. The greater needs of non-acid users notably sulphite pulp and viscose rayon manufacture were met in the first place by increased elemental sulphur supplies which rose 157,000 tons (26%) while the use of sulphur in pyrites notably in Scandinavian and German sulphite pulp mills rose 90,000 tons (18%).

While the importance of the various statistical changes cannot be ignored, they would be misleading if full account were not taken of the new emphasis on the role of brimstone supplies from overseas. The greater liberalisation of trade and payment facilities, the desire and in some cases even the need of Frasch sulphur producers to find markets for their new production gives elemental sulphur more weight in the assessment of consumption trends in the coming years. Yet even so the overall picture needs to be viewed in the detail of its constituent parts which in the case of the sulphur industries of Free Europe range from those wholly self-sufficient to some wholly dependent on outside sources of sulphur supply. Amongst the former little if any change in the pattern of sulphur consumption has occurred, nor is this likely to.

Spain 351,000 m.t. (16% Br. 77% Py. 7% Other) *
Portugal 110,000m.t. (17% Br. 83% Py.)
Greece 57,000 m.t. (18% Br. 75% Py. 7% Other)

The domestic acid industries, based almost exclusively on the use of pyrites, are engaged in a long term expansion programme which is primarily intended to ensure the greater output of fertilizers. Augmented by occasional modest imports of elemental sulphur, domestic supplies, which in Spain and Portugal are also based on pyrites, are expected to be adequate to meet slowly rising non-acid requirements. Recovery of sulphur in Spain and Greece in connection with the use of the brown coal as fuel and a source of nitrogen could assume major proportions as financial and technical economies become available. In Spain, by-product acid recovery from smelter gases in conjunction with zinc smelters, now under construction or in the planning stage, cannot fail to make a useful contribution.

Italy 837,000 m.t. (13% Br. 76% Py 11% Other)

The demarcation between the exclusive pyrites use by the sulphuric acid industry and elemental sulphur by non-acid users has remained decisive until about two years ago. Since then use of low grade sulphur ore in acid manufacture has been rising, the inducement being twofold: from the sulphur miner's point of view a new and not unprofitable outlet and to the acid maker a cheap and plentiful source of supply. Notwithstanding the large output of pyrites and brimstone, rising imports of pyrites for acid manufacture make Italy a net sulphur importer. The ambitious plans of the Italian Government for agriculture and kindred industries, notably in the south of the country will inevitably be reflected in greater sulphur requirements and the present trend of rising use of low grade sulphur ore could well meet this need.

* Statistical details show sulphur consumption in 1955 and the percentage of use of Brimstone (Br.), Pyrites (Py.) and Sulphur in other forms.

Scandinavia

Denmark 69,000 m.t. (2% Br. 87% Py. 11% Other)

Finland 150,000 m.t. (33% Br. 50% Py. 17% Other)

Norway 100,000 m.t. (26% Br. 56% Py. 18% Other)

Sweden 305,000 m.t. (22% Br. 73% Py. 15% Other)

The dominant position of sulphite pulp amongst the consuming industries of Norway, Sweden and Finland has always enhanced the value of Norway's and Sweden's elemental sulphur production, without however making the industry dependent on sulphur supply in this form. On the contrary the majority of pulp producers use pyrites for SO_2 manufacture and use elemental sulphur in emergencies only. Nevertheless since mid 1954 the economic advantages of brimstone use have been reflected by rising imports into Sweden and Finland from the U.S.A., Mexico and Chile. These overseas sources of supply may be expected to augment their share of the Scandinavian market unless the current demand for brimstone is met either by greater or possibly new brimstone supplies recovered from Norwegian pyrites or Swedish shale oil. A large proportion of the sulphuric acid supplies, predominantly used for fertilizer manufacture, is already recovered from smelter gases in Norway, Sweden and Finland and the impact of brimstone, though as yet not very pronounced in this section of industry, is already felt. No change appears to be indicated in Denmark where the important acid/fertilizer output remains pyrites based.

Belgium 400,000 m.t. (17% Br. 48% Py. 35% other)

The large-scale recovery of sulphur in the form of by-product sulphuric acid from smelter gases of non-ferrous ore, especially zinc blende, forms the basis of Belgium's acid industry, which not only supplies the domestic fertilizer industry, one of the few essentially dependent on exports, but also exports sulphuric acid to neighbouring Holland and Western Germany. Proximity and cheap transport facilities to pyrites residues plants in Germany confer on pyrites many advantages over competing brimstone supplies. Marginal advantages dependent on location and market fluctuations are likely to determine the development of this market, which may be strengthened before long by greater non-acid requirements of elemental sulphur.

Holland 225,000 m.t. (1% Br. 91% Py. 8% Other)

Although the industry had been almost exclusively based on the use of pyrites for over 50 years, two important manufacturers decided in 1955 to base new plant on the use of brimstone. This new capacity and others now under consideration aim to remove the need for acid imports. Although useful as supplementary sources of supply, recovery of sulphur from zinc smelter and particularly oil refinery gases, which is being boosted, plays only a relatively

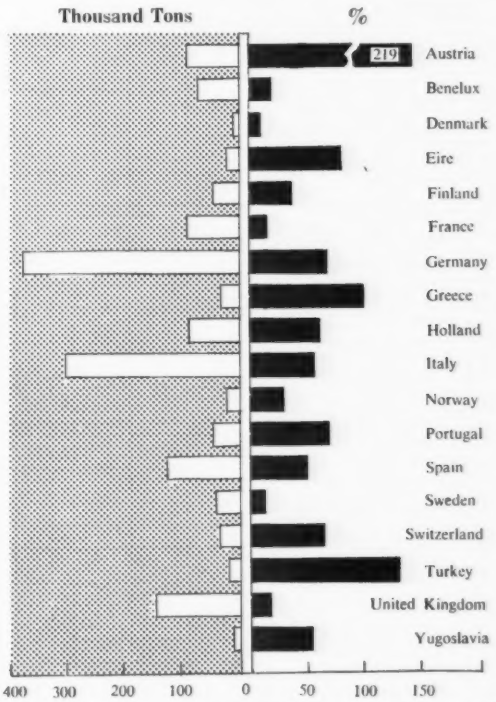


Fig. 2. Increase in Consumption of Sulphur in all forms, 1949/50 to 1955.

minor part. The form in which the future expansion of sulphur needs is to be met may well be determined by the view taken on trends in shipping freights.

Western Germany

938,000 m.t. (10% Br. 75% Py. 15% other)

Following the very large expansion of consumption, the German sulphur industry is the only major European importer firmly based on pyrites use. As the layout, location and balance of the industry has been built upon the basis of adequate transport facilities and residues usage, there is little indication of major inroads by brimstone use for acid

manufacture, especially since the installation, in recent years, of fluidised-bed pyrites roasters at most new plants. Favourable operating economics strengthen the attraction of pyrites use although there are problems, especially in the case of arsenical pyrites, arising out of the quality of the resultant residues and their suitability for subsequent treatment which remain to be solved. Use of recovered sulphur and H_2S from coal, oil refining and natural gas is playing an increasing part, but the growing demand of regular sulphur users is reflected by greater imports from U.S.A., Mexico and Chile.

United Kingdom

1,077,000 l.t. (36% Br. 20% Py. 44% Other)

The United Kingdom sulphur industry, the largest sulphur user in Western Europe, has twice in five years completely changed its policy under the impact of fresh world market developments. Elemental sulphur use has been boosted since the termination of national controls at the end of 1955, without however upsetting the balanced pattern of consumption mainly because of the existence of substantial anhydrite acid manufacturing capacity. The advantages of brimstone use to United Kingdom users are evident from the trend in new plant manufacture, but what proportion of growing demand may be met by recovery is as yet not clear.

France **678,000 m.t. (29% Br. 58% Py. 13% Other)**

Overshadowing all past developments of the French sulphur industry is the imminent large-scale supply of recovered sulphur from the Lacq gas fields. Dependent, of course, on the new industry's ability to place the cleaned natural gas, the supply of recovered sulphur from early 1957 onwards will not only change the domestic pattern of consumption but may affect the supply picture in neighbouring countries.

Other Countries

Austria **130,000 m.t. (19% Br. 22% Py. 59% Other)**

Eire **39,000 m.t. (100% Py.)**

Switzerland **79,000 m.t. (66% Br. 34% Py.)**

Turkey **21,000 m.t. (52% Br. 43% Py. 5% Other)**

Yugoslavia **29,000 m.t. (16% Br. 74% Py. 10% Other)**

Of the remaining countries only Switzerland and Eire, both wholly dependent on imports of all sulphurous raw materials, may be expected to show a significant swing towards brimstone use. In Eire the position is complicated by the development of indigenous pyrites resources which may be difficult to use economically in the existing pattern of the industry.

In Turkey and Yugoslavia the projected large-scale use of sulphur in smelter gases offers the means of ensuring acid supplies in keeping with ambitious chemicals and fertilizer programmes.

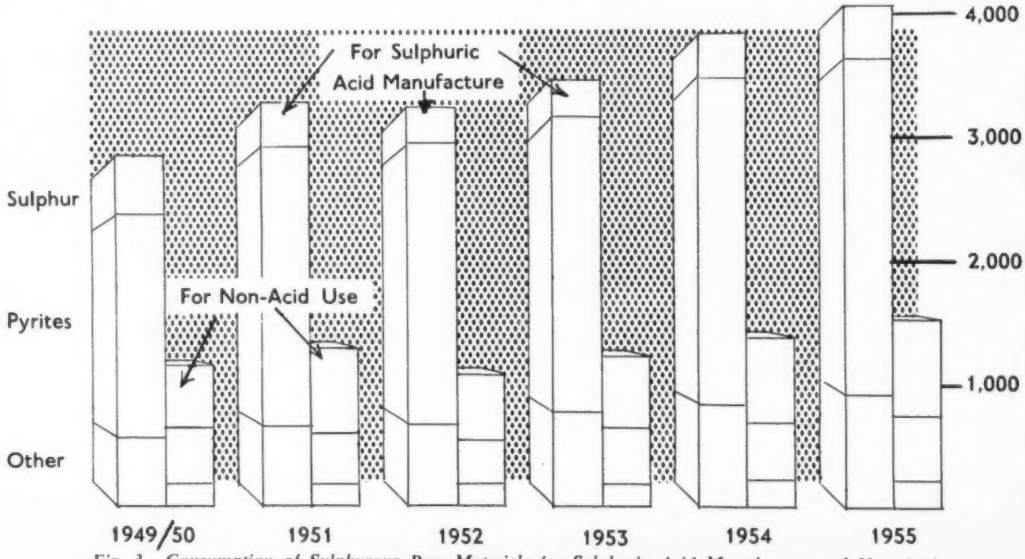


Fig. 3. Consumption of Sulphurous Raw Materials for Sulphuric Acid Manufacture and Non-Acid uses in Free Europe (Thousands Tons Sulphur).

Outlook

At the end of 1955 Western European sulphur consumption of 5½ million tons was divided between brimstone 21%, pyrites 59% and other forms 20%. Although the indications of likely changes in Europe's pattern of consumption cannot be accurately expressed, several factors stand out clearly. Pyrites usage in Western Germany remains as firmly established as ever and with the country's expanding economy will continue to grow. It is slowly declining in Holland but more quickly in U.K. and Belgium. There is every indication that in the last mentioned countries brimstone use is on the ascendant, but with the exception of France, it is unlikely that brimstone will attain a dominant position.

In the past five years the average rate of increase of sulphur consumption in all forms was about 6½%. It is improbable that so high an average rate may be maintained, especially as Germany, now the second-largest user, having completed reconstruction, may be expected to develop more steadily. Developments in fertilizer manufacture which takes up about 57% of sulphuric acid consumption or over two-fifths of Free Europe's sulphur use, provide an important yardstick. The growth of production of ammonium sulphate is likely to slow down under pressure of supplies of other nitrogenous fertilizers. The expansion of single superphosphate production is now not expected to exceed 4% per annum, primarily on account of the greater availability of P_2O_5 in basic slag resulting from increasing steel output. There are as yet no indications that the growth of phosphoric acid manufacture, determined almost exclusively by the merit of high concentration fertilizer, notably triple superphosphate, is being affected by the added inducement of uranium oxide recovery from the relatively rich North African rock. At an average expansion rate of 3%-4%, sulphur consumption in Western Europe in 1960 is indicated at 6½-6¾ million tons. The rate of growth of the viscose rayon, pulp and other non-acid industries is not expected to outpace sulphuric acid needs. Whereas in the more advanced industrial countries uses other than fertilizer production —notably titanium dioxide and detergents— are expected to advance most rapidly, the overall position should be balanced by intensive fertilizer programmes in the less developed economies.

It is evident that of the additional demand of 1-1¼ million tons sulphur at least one-third will arise in wholly self-sufficient countries, where the domestic resources may be expected to meet the rising requirements as a matter of course. For the rest of Europe's demand which is partly or wholly imported even if, as in the case of the bulk of pyrites shipments, the movement is only from one part of Free Europe to another, the expansion of sulphur recovery facilities is automatically reflected in quantitative changes of import demand. The effect of the anticipated large-scale brimstone recovery at Lacq could therefore be far-reaching in supplanting by 1960 one quarter million tons or possibly more of sulphur in pyrites or imported U.S. or Mexican brimstone. The division of the residual demand upon world sulphur trade and concurrently any changes in the existing pattern are largely determined by the economic merits of brimstone against pyrites use. The abundance of present supplies of brimstone and the prospect of early exploitation of additional domes have not only resulted in significant reductions in f.o.b. costs of U.S. and Mexican brimstone but, by virtue of disparity between the rates of growth of output and markets, is forcing brimstone producers to press for new outlets at the expense of pyrites. In this endeavour the present boom in shipping freights is frustrating both to shipper and consumer. What is more, the uncertainty of recurring booms or boomlets, mainly on account of heavy programmes of transatlantic coal shipments scheduled for years ahead, prevent the re-establishment of a more stable price relationship between brimstone and pyrites.

Anticipating the continuation of the present highly competitive market conditions the Frasch sulphur shippers would above all like to see a reduction in sea freights in relation to the f.o.b. costs. To this end much thought is being given to the many problems of liquid sulphur shipments, in the hope of implementing the overt savings to producer and consumer. To the principal pyrites exporter, Spain, the expedient of an adjustable special exchange rate offers much scope for relative

price reductions which most other producers especially those shipping by-product pyrites concentrates can be expected to follow. It may be expected that by the end of the next five-year period, requirements in Free Europe will necessitate an increase of imports of one - half million tons per annum of brimstone and sulphur in pyrites. Such competitive conditions of supply and the absence of stability in transportation charges point to recurring adjustments of respective prices and costs.

Prices and Trends

Prices

IN common with other commodities the cost of sulphur has been seriously affected by the exorbitant rise in sea freights during the past three months. Charters concluded in this period are raising the landed costs of brimstone, the world price of which has remained stable, by over 10% in Europe and due to the greater freight rise, on account of the dearth of shipping space East of Suez, by about 25% in the case of Australian and Indian destinations.

Producers in the U.S.A are basing their f.o.b. prices on $28 per ton of bright sulphur for shipment to domestic and overseas customers. In the case of off-colour sulphur delivered by Texas Gulf and Freeport Sulphur Companies a quality discount of $1 per ton is uniformly granted. Although faced with rising costs—the general price level in the U.S.A has advanced by over 3% in the course of the year—U.S. producers appear to be determined to avoid for as long as possible a rise in the present level of sulphur prices. In this connection it is of interest to note that an attempt in July 1956 by the Louisiana Legislature to raise the sulphur severance tax from $1.03 to $3 per ton of sulphur was sharply and successfully contested by the Freeport Sulphur Company.

In Mexico sentiment as regards price policy appears to vary between individual Frasch sulphur producers. Pan American Sulphur Company now in their third year of operation and with a sizeable and expanding Order Book, give the impression of favouring firmer prices. The company's ability to ship purer sulphur, since the completion of a filtering plant last autumn, would seem to strengthen the management's desire to raise the price wherever market conditions permit toward the upper level of the apparent selling price bracket of $24-$26.50 per ton f.o.b. Gulf Sulphur Corporation, on the other hand, whose dome has been in production only since last May, is intensively engaged in building up a clientele throughout the world and understandably, its management appears to favour a more flexible price policy. The start of operation in Mexico by Texas Gulf Sulphur is awaited with much interest as the company's policy with regard to shipments and prices cannot fail to affect other producers.

In Chile no further action is reported to have been taken by the Government in answer to the sulphur producers' request for special exemption from the new regulations terminating commodity compensation transactions. Beyond those executed by the end of 1956 no further permits are reported to have been granted. Continued inflationary pressure is pushing up the costs of sulphur mining and refining and even with free market exchange rates of about Peso 550 to U.S. $1, it is doubtful whether the competitive export prices which appear to be in the region of U.S. $20-$22 per ton f.o.b. are adequate to allow profitable production.

On account of the greater landed cost of U.S. and Mexican supplies, the price of Italian and Scandinavian sulphur as well as that of many other indigenous producers has risen. Following the now established practice of quoting competitively in selected markets, Italian exports to neighbouring destinations are reported to have been maintained satisfactorily and it estimated that returns for spot cargoes are on average about Lire 2,000 higher than three months earlier. Based on a price of

about Lire 25,000 per metric ton (£14 10s. per ton) f.o.b. for Gialla Inferiore (min. 99% S), Enti Zolfi Italiani has been able, in the case of the bulk of recent export contracts, to limit recourse to the available subsidy. Although better able to do so than earlier in the year, there have been no indications of Italian sulphur attempting to compete in more distant markets.

The following table shows a comparison of prices of sulphur of different origin. F.o.b. prices and freight are based on recent quotations or indications :—

	f.o.b. Country of Origin	*Freight to U.K.*	*per ton c.i.f. U.K.*
U.S.A.	U.S. $27—28	125/-	£16 —16¼
Mexico	U.S. $24—26.50	125/-	£14⅞—15¾
Italy/Sicily	L. 23,000—25,000	65/-	£16¼—17¼
Chile	U.S. $20—£22	165/-	£15⅝—16⅛
Ecuador	U.S. $42	165/-	£23¼
Canada	Can. $20 ex-works	150/-	£20¼

Pyrites

European producers of pyrites are reported to be maintaining export prices for the first half of 1957 at £4. 10s. to £5 per metric ton f.o.b., the level to which they had been reduced in mid-1956. Charters concluded at the peak of the recent freight rise are adding up to 15% of landed costs on the Continent. The effect of high freights on residue values is widely expected to be favourable, as higher iron values should go a long way toward balancing the decrease in copper values over the past 6 months.

Freights

Following the blocking of the Suez Canal, tramp freights have risen to an all-time peak partly on account of the shortage of cargo-space occasioned by the longer haul round the Cape but equally due to orders, deferred during the uncertain weeks of the early autumn, being forced to come on to the market. The rise in trans-atlantic rates of over 40% and of those to the Far East by about 60% has been fully reflected in sulphur freights. The volume of charters from U.S. and Mexican Gulf ports at the highest rates of 140-145s. to European ports was however strictly limited. By the end of the year rates of 125-130s. for Gulf to the Continent could be secured.

In spite of some reductions, end-of-year sulphur freights are still up to 15- 30% above the pre-Suez crisis average rates, Australia and India being most adversely affected. Liner terms which gave some relief at the peak of the market are due to be increased by the majority of Liner Conferences during the first quarter of 1957 by about 10%. Pyrites freights were as seriously affected at the peak of the market as all other trades but generally rates took longer to rise and receded more quickly. In the case of handy-sized vessels for Huelva to Continent, which in October could be secured for 40s. rates rose slowly to a peak of 53s. mid-December and then receded to about 46s. by the end of the month. Due to the lack of available vessels, the differential for the Eastern Mediterranean rates widened substantially.

Steps to reduce pressure on freights are reported to have been taken by O.E.E.C. The Council has instructed Committees responsible for coal and maritime transport to give urgent consideration to possibilities of (1) limiting countries' demand for dry bulk cargoes (2) spreading shipments over longer periods (3) planning orders for tonnage as far in advance as possible.

Since trans-atlantic coal shipments to United Kingdom and Western Europe are at the root of the problem, the reduction of liquid fuel supplies by the blocking of the canal cannot fail to aggravate the overall position. The recent easement of the freight market represents little more than a retreat from extravagant positions and the outlook for a reduction of sulphur freights from Gulf to Europe to below 100s., at which level sea freight would equal about 50% of the prime cost of Frasch sulphur, is not promising.

Supplies

In the U.S.A. the continued high level of operations at most domes resulted in peak production; twelve domes were operating at the close of 1956, one less—Freeport's Nash dome—than at the beginning of the last quarter. Frasch sulphur deliveries to domestic and export markets, however appear to be

about the same as last year so that the substantial excess output is added to producers' stocks. The strong up-surge of domestic sulphur demand toward the close of the third quarter and in the last quarter, reflecting the acid needs of steel, fertilizer, titanium and oil industries, and to a lesser extent sulphur needs for pulp, rayon, rubber production, has been met in the first place by record deliveries of recovered brimstone and imported Mexican sulphur, leaving domestic Frasch sulphur to meet residual—albeit the bulk—requirements.

In Mexico annual output of about 650,000 tons appears to have been achieved by the two active producers, Pan American Sulphur Company and Gulf Sulphur Corporation. After record shipments to U.S.A. and to world markets of close on ½ million tons, significant additions to stocks are estimated to have raised these to about 450,000 tons. The completion of a filtering plant at Jaltipan and the imminent start of a similar plant at Las Salinas in February, gives Mexican supplies the merit of good quality, in addition to the existing advantages of low water requirements and production costs and, of course, lower export prices. The imminent start of operation by Texas Gulf Sulphur Company at Santa Anita, promises to intensify competition, while the ambitious exploration, development and plant construction programme of Texas International Sulphur Company promises further to raise potential and actual dome capacity by the end of 1958.

In Italy expanding mine output of sulphur ore is increasingly being directed to sulphuric acid manufacture, while refined sulphur production is taking up a smaller tonnage. Reduced output of refined sulphur, coupled with greater exports compared with last year helped to reduce the stockpile to about 286,000 tons by the end of November.

Indecision about the future ability of Chilean sulphur supplies to compete in world markets is reported to have slowed down production in recent months when customarily the end of the Chilean winter is marked by a surge in output.

In Japan a significant expansion of output appears to have been achieved which has narrowed the gap between supply and demand. There are conflicting reports about the need for further imports before the end of the fiscal year on 31st March, but it appears likely that at least one more cargo may be imported.

Recovery

Whereas a slight reduction in the output of recovered sulphur at oil refineries in Europe may be expected during the coming months, on account of the enforced cut-back in refinery throughput, the outlook for increased supplies of recovered sulphur is bright. In Canada and France, natural gas cleaning plants are due to start yielding high purity brimstone in the course of the next few months and in Iraq the important scheme for a cleaning plant at Baghdad based on Kirkuk sour gas, although postponed until the resumption of oil deliveries and revenue restore its necessary finance to the Development Board, will doubtless be realised. Envisaged expansion and new construction plans of oil refineries promise to add over the coming years tens of thousands tons of sulphur recovery capacity in the United Kingdom and in Europe and much more in the U.S.A. where in addition recovery of sludge acid plays an increasingly important part. A significant increase in by-product acid facilities is also taking place in all parts of the world. Based on nickel and zinc in Canada, lead, zinc and copper in U.S.A., copper in Chile, zinc in Spain and Australia, known schemes represent in part new sources of non-ferrous metal production, as well as means of making use of sulphur hitherto wasted to the atmosphere at established installations.

Pyrites

No significant increase in demand appears to be imminent. Lower requisitions in U.K., Belgium and Sweden are likely to be balanced by greater demand in Germany, Italy, Spain and Portugal. European production capacity has increased following the start of operation of the Gjersvik mine in Norway and the discovery of important pyritic ore-bodies by the Esperanza Sulphur and Copper Company on Cyprus.

Excessive freight rates may prevent Cuban and Canadian pyrites reaching Europe, but the deficiency, if any, can comfortably be met by European producers. Greater demand is reported to be manifest in Eastern Europe,

where Scandinavian and Jugoslav pyrites are finding a ready outlet.

In Canada domestic pyrites demand is reported to be much stimulated, primarily by the start of the Noranda Sulphur/SO_2 plant of Algom Uranium Mines Ltd.

Summary

The heavy increase in sea freights is adversely affecting the movement of sulphur and pyrites, while at the same time in Europe it is stimulating the use of indigenous, notably recovered, sulphur supplies. World supplies of brimstone have risen to an unprecedented level, on account of peak output in the U.S.A. and in Mexico, and while consumption is slowly rising, world stocks of brimstone appear to have increased by about 1 million tons in 1956. There are signs that the weakness of the statistical position is no longer as fully reflected by prices but there is nevertheless no doubt of the continuance of highly competitive conditions in the world sulphur trade.

UNITED STATES SULPHUR

Native Sulphur

PRODUCTION of Frasch sulphur during the third quarter of 1956 which totalled 1,743,199 tons was 8% greater than the previous quarter and 17¼% greater than the corresponding period last year. Despite the recession in the general level of production particularly in July when, occasioned by seasonal factors coupled with the steel strike, the unadjusted index fell 13 points to 128 (1947/48=100) sulphur production rose to record levels; the peak was reached in July when 621,130 tons were mined by the Frasch process.

Sulphur consumption is likewise running at a record level, although of the total produced during the third quarter 350,000 tons has been added to stocks. Producers are at present increasing their ratio of stocks to sales, as it is thought that with the present high level of consumption future deliveries will not be sufficiently safeguarded should world events upset the present equilibrium. Apparent sales of 1,514,934 tons were 5¾% lower than the preceding quarter but exceeded those of the corresponding period last year by 2¼%. Apparent consumption of elemental sulphur was however running about 7% higher than the third quarter last year principally on account of the higher level of imports from Mexico coupled with the increased output of recovered sulphur, which was readily absorbed in local markets. It is estimated that imports from Mexico, consigned almost exclusively to acid makers on the Atlantic Seaboard, totalled about 68,000 tons during the third quarter. Exports of Frasch sulphur reached a quarterly record total of 463,072 tons compared with 434,464 tons during the same period last year.

The steel strike, although complete, did not significantly affect the sulphur consuming industries and in effect has probably resulted

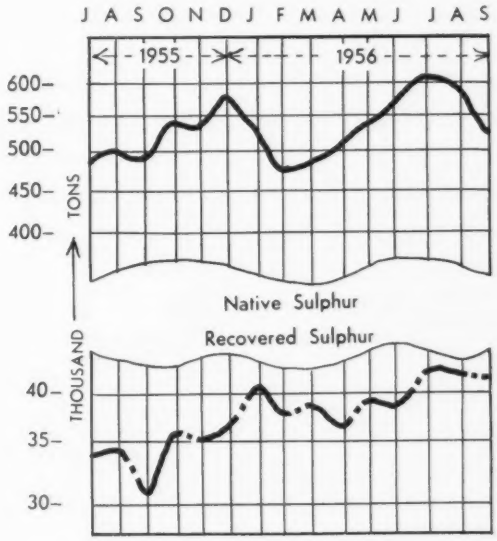


Fig. 4. Monthly Production.

in a greater industrial upswing for the start of the fourth quarter than could have otherwise been anticipated. Sulphuric acid production during July of 1.13 million tons was higher than in July 1955 and the quantity usually absorbed for steel pickling and coke-oven ammonium sulphate manufacture was readily taken up by the producers of wet process phosphoric acid and the manufacturers of superphosphates despite already high stocks and the present unwillingness of the agricultural market to buy fertilizers. By the middle of August the steel industry was well back into production

and in order to make up the back-log of orders was operating in excess of capacity at the end of September.

Sulphuric acid production similarly showed a strong increase and the third quarter's acid production of 3.58 million tons was fractionally higher than for the same period last year. All acid consumers have shown a higher usage and consumption may be expected to reach peak levels by the end of the year.

The high rate of sulphur production has resulted in a considerable rise of producers stocks which totalled 3,680,784 tons at the end of September compared with 3,330,433 tons at the end of June and 3,000,346 tons at the end of September last year.

Recovered Sulphur

Production of recovered sulphur during the third quarter totalled 127,900 tons, the largest total yet produced from natural and oil refinery sour gases, and was 15,000 tons (13¼%) greater than the previous quarter and 29% greater than the corresponding period last year. A further plant for the recovery of sulphur from refinery gases was put on stream during the quarter. Located at Billings, Montana, the plant is operated by the Montana Sulphur & Chemical Company and obtains its sour gas from the local refineries of the Carter Oil and Consolidated Oil Companies; it has a capacity to produce daily 40 tons of high purity elemental sulphur.

Apparent sales of recovered sulphur in the third quarter of 122,086 tons were likewise a record and exceeded those of the previous quarter by 2,200 tons. Stocks of recovered sulphur rose to 117,758 tons by the end of September, a rise of 3½% compared with stocks at the end of June.

Summary Third Quarter 1956

(a) Production of both native and recovered sulphur set new record levels totalling 1,871,099 tons of elemental sulphur. This high level is not directly related to the present consumption pattern, but determined by the individual producers policies relating to production and stocks.

(b) Apparent sales of native and recovered sulphur totalled 1,514,934 tons, the highest third quarter's total on record and 2½% more than the corresponding period last year. Domestic consumption has for the first nine months exceeded that of the same period last year by approximately 9% and this pattern was not seriously upset by the steel strike during July, although it is believed that consumer stocks increased.

(c) Stocks of native and recovered sulphur at the end of September totalled 3,798,043 tons compared with 3,442,428 tons at the end of June.

1956 Review

MR. LANGBOURNE M. WILLIAMS, President of the Freeport Sulphur Company, sums up sulphur development in the U.S.A. during 1956 in his now traditional year-end review:—

"Production and consumption of sulphur in the United States reached new highs in 1956 and exports of the yellow mineral held near the record levels of the past few years. Output of sulphur from all sources increased to an estimated 7,875,000 long tons, or 825,000 tons more than in 1955. More than four-fifths of the total production came from the salt dome deposits of Louisiana and Texas. These deposits, which are mined by the Frasch hot water process, produced an estimated 6,450,000 tons compared with 5,750,000 tons in 1955. Of the balance of the supply, 500,000 tons represented sulphur recovered from gases, 425,000 tons sulphur contained in pyrites, and 500,000 tons sulphur in various forms from other sources.

"Consumption of sulphur in the United States was estimated at 5,900,000 tons compared with 5,650,000 tons in the previous year, and exports were expected to about equal the 1,600,000 tons shipped in 1955.

"Thirteen Frasch process mines operated during the greater part of the year. Texas Gulf Sulphur Company, the largest producer, operated three in Texas; Freeport Sulphur Company, four in Louisiana and one in Texas; Jefferson Lake Sulphur Company, two in Texas and one in Louisiana; and Duval Sulphur and Potash Company and Standard Sulphur Company one each in Texas. In November, Freeport closed its small Nash mine located 35 miles south-west of Houston.

"The development of two new mines—the Lake Pelto, Louisiana, property of Freeport, and the Fannett, Texas, deposit of

Texas Gulf—was under way in 1956 and plans to mine an additional new deposit were announced.

" The new deposit, known as Grand Isle-Block 18, is located off Louisiana in 45 feet of water six miles from the nearest land. Freeport is working on plans to install facilities there which will mark the first completely off-shore sulphur mining operation ever undertaken. Exploratory drilling by Humble Oil and Refining Company established the existence of the deposit which is considered to be one of the most important sulphur discoveries of recent years.

" New sources of sulphur, other than Frasch process mines, which came on stream in the United States during the year include five projects to recover sulphur from refinery gases and four from natural gas. In addition, six plants which recover sulphur from refinery gases were expanded. The total new productive capacity of all of these projects is about 300,000 tons annually.

" In spite of the greater demand for sulphur during the year, little change occurred in the use pattern by industries. About 80 per cent of the mineral consumed was converted into sulphuric acid and the remainder used in elemental form or in other chemical compounds. In one form or another sulphur is used to produce fertilizers, paper, chemicals, steel, gasoline, rubber, textiles, paints and many other necessities.

" The year 1956," Mr. Williams concluded, " marks the third consecutive year in which production and shipments of sulphur by domestic producers have attained new highs, a condition attributable to the versatility of sulphur and to the continued high level of the economy."

Drilling Rig at Lake Pelto Dome.

By-Product Sulphuric Acid Production by the Bunker Hill Company

THE start of operations in April, 1954, of a by-product sulphuric acid plant at the Company's lead and zinc smelting installations at Kellogg, Idaho, marked a notable development in the history of the Bunker Hill and Sullivan Mining and Concentrating Company, one of the oldest lead-zinc ore mines in Western U.S.A., first incorporated on 29th July, 1887. In recent years the Company's interests have become so diversified that the original title no longer accurately described its activities, and was thus changed early this year to The Bunker Hill Company. At the same time non-mining interests such as electric power distribution were abandoned in order, as recently announced by the *President, Mr. J. D. Bradley*, to devote all energies and resources to lead, silver and zinc ore mining, smelting and kindred activities at established sites, and to promote exploratory work in Alaska and North-West Canada.

Sulphuric Acid

The decision to make use of the sulphur content of the sulphide ores, which as sulphur dioxide had hitherto been vented to the atmosphere with exit gases, sprang partly from the Company's own sulphuric acid needs in the electrolytic zinc plant but principally from the growing sulphuric acid requirements for metallurgical purposes at nearby non-ferrous mining and refining installations.

During a four months' trial period—from April to August 1954—the new by-product sulphuric acid plant using the SO_2 gases, resulting from the roasting of zinc concentrate, produced 9,689 short tons (100% H_2SO_4). Restarted in February, 1955, it remained in operation for the rest of the year and working a little under 50% of capacity it produced 48,326 short tons acid (100% H_2SO_4) or $6\frac{1}{4}$% of the total output of by-product sulphuric acid at zinc plants in the United States.

Description of Plant and Operations

A Leonard-Monsanto contact acid plant of standard design, it is rated to produce 300 short tons of 100% H_2SO_4 per 24 hours in the form of 93.2% H_2SO_4 (66°Bé) or 98-99% H_2SO_4. A 74 H Type " P " blower, driven by an Elliott 2Eo2 steam turbine propels the exit gas steam from the roaster through the acid plant in the course of which, subjected to the conventional processing steps of purification, conversion and absorption, waste SO_2 gas is recovered as sulphuric acid.

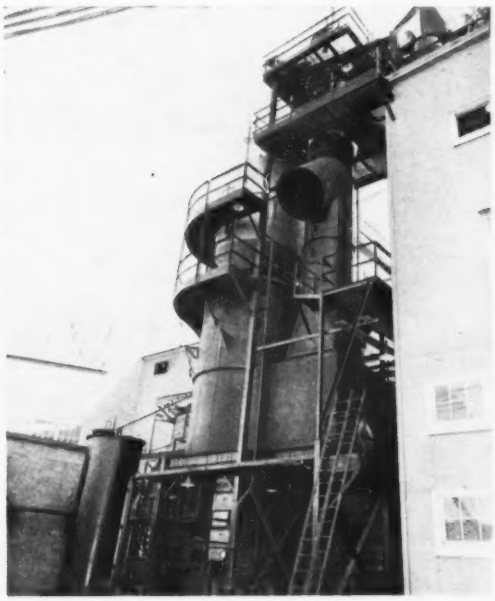
Purification: Roaster gas after leaving a Cottrell electrical dust precipitator is led to a Peabody scrubbing and cooling tower where water removes many of the impurities and cools the gas to the required temperature. The water discharged from the tower contains the impurities removed from the gas and will also be saturated with SO_2 from the gas. In order to recover sulphur values, as well as to reduce effluent nuisance, the water from the tower passes through a stripping column where a stream of air removes most of the SO_2 and the water from the stripping column is then allowed to run to waste.

Sulphuric Acid Installations.

From the scrubbing and cooling tower the gas is then passed through a mist precipitator in which most of the remaining particles of acid mist, metallic fume and dust are removed by electrical precipitation. In a drying tower

the purified gas is then subjected to a counter-current flow of strong sulphuric acid, usually 66° Bé (93.19%) or higher, whereby most of the water vapour is removed from the gas. All equipment to this point is operated under suction from the blower. The Peabody scrubber is made of stainless steel while the mist precipitator and duct work to the drying tower are lead.

Conversion: Clean gas leaving the drying tower is forced through the rest of the plant by a blower. The conversion of SO_2 to SO_3 takes place in a three pass converter, containing four layers in three sections of vanadium pentoxide catalyst—a total of 42,000 litres—and equipped with heat exchangers to make use of heat generated as the SO_2 is converted to SO_3. The gases are taken from the converter twice, cooled in the heat exchangers, and fed back



Zinc Concentrates Roasters.

again to the next section of the converter. Part of the heat thus removed by the heat exchangers is transferred to the cold SO_2 gas leaving the blower. By-pass valves are provided around the heat exchangers so that the temperature at the inlet of each section of the converter may be controlled, but all of the gas goes through all three sections of the converter, thus obtaining the maximum conversion efficiency. Upon leaving the converter, the gas passes through one of the heat exchangers and an SO_3 cooler which reduces it to the correct temperature for admission to the absorption system.

Incorporated in the converter system is a preheater which is required only on initial start-up or when starting the plant after a shut-down of such length that temperature in the catalyst has fallen below the point where reaction would take place when the SO_2 gas is again admitted.

Absorption: SO_3 gas from the converter is fed through an absorbing tower where it is scrubbed with 98-99% acid, and thus indirectly combined with water. The acid in the absorbing tower pump tank is maintained at the correct strength for absorption of SO_3 gas by the addition of acid from the drying system. In both cases water dilution is also used to control the acid strengths when needed.

Coolers ahead of the acid pumps, which deliver acid to the drying and absorbing towers respectively, reduce acid temperature to the correct level.

Summary

Operating at full capacity of 300 short tons per day the sulphuric acid plant—the first to be built in Idaho— is adequate to make use of all the SO_2 contained in the exit gases of the zinc concentrate roaster working at full capacity. Expansion work is, however, at present in progress which when completed will raise the treatment capacity of the zinc concentrate by 50%. The resultant greater volume of SO_2 in the exit gases would warrant a corresponding expansion of the acid plant but this is not foreseen until an assured market for the greater potential output is found. The sulphurous exit gases of the lead smelter at Kellogg are not at present used for sulphuric acid manufacture although when justified this source of sulphur supply will not be neglected. The Bunker Hill Company has in its two metallurgical plants adequate means to produce 800-900 tons per day of low-cost sulphuric acid and with the growth of nearby markets this economic source of supply cannot fail to expand toward its fullest potential.

Sulphur Recovery at Marcus Hook Oil Refinery

General

THE Sinclair Refining Company operates sulphur recovery units at their Marcus Hook, Pennsylvania and Houston, Texas refineries. Currently, the combined sulphur production at these refineries total 100 short tons per day while the capacity of the two refineries is estimated at 135 short tons per day.

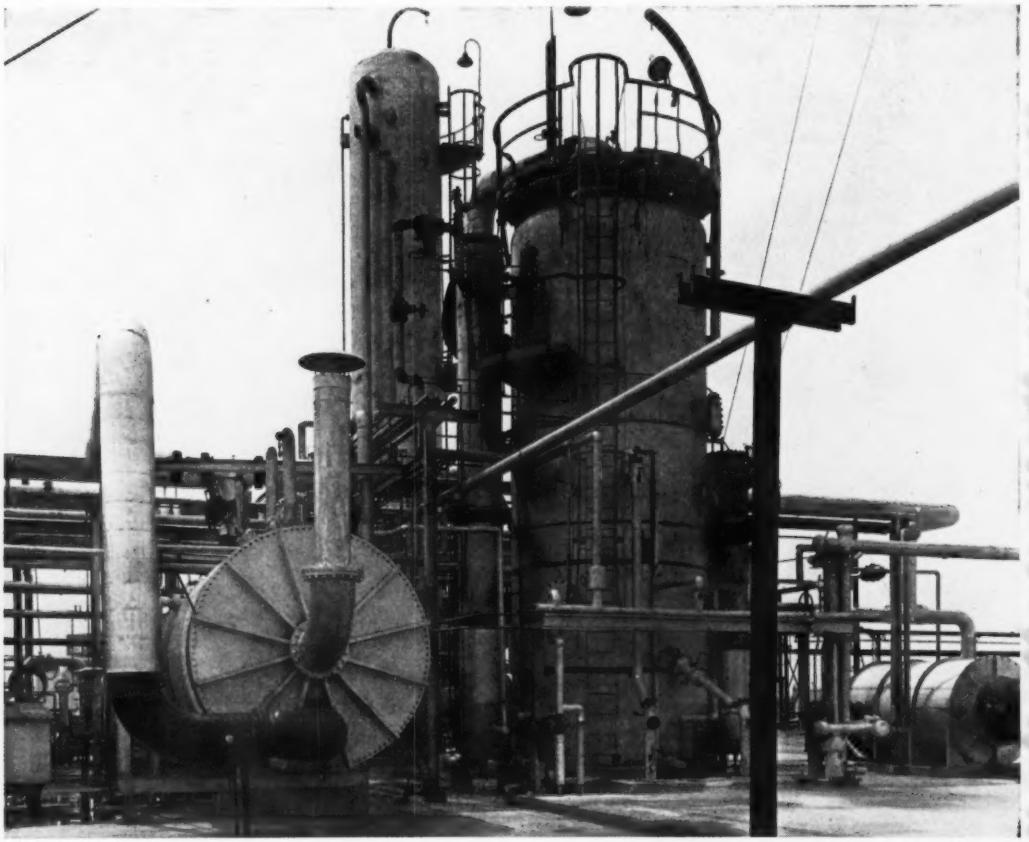
The sulphur recovery units receive acid gas containing up to 80% hydrogen sulphide as a process stream and convert the hydrogen sulphide gas to molten sulphur. By extracting the hydrogen sulphide from process streams to furnish the feed to a sulphur recovery unit, refiners realize other benefits in addition to the profits realized from the sales of sulphur.

The additional benefits are as follows :-

(i) Elimination of air pollution problems where acid gases had previously been disposed of by burning under boilers or at flares.

(ii) Reducing the maintenance costs and improving the burning efficiency of such boilers that had disposed of acid gases.

(iii) By extracting hydrogen sulphide from all fuel gases, considerable maintenance savings result by reducing drastically the corrosion of air preheater elements, boiler tubes, stacks, gas lines, control valves, metering installations, induced draft fans, flue gas ducts, refractory and burners that are associated with all fuel burning equipment.



Condenser Column and Converter Unit at Marcus Hook Refinery.

Hydrogen Sulphide Extraction Operations

At the Marcus Hook refinery, four separate H_2S recovery units are employed to extract the hydrogen sulphide from practically all the refinery gas streams as well as from a liquified propanes-butanes fraction feedstock for a high pressure polymerization unit. Basically, the hydrogen sulphide operations are the same for all the process streams. The process streams enter near the bottom of their respective extractors and flow upward through packed beds of Raschig rings or bubble trays. A solution of diethanolamine is fed to the extractor above the Raschig ring bed and flows downward contacting the process stream. The Raschig rings afford thorough contacting for the counter-current streams and the hydrogen sulphide contained in the process stream is extracted by the amine solution.

The scrubbed, or essentially hydrogen sulphide free, process stream leaves the top of the extractor while the foul amine solution containing the hydrogen sulphide leaves the bottom of the extractor and is fed into an amine regenerator.

A steam reboiler supplies the necessary heat input to the regenerators to strip out the hydrogen sulphide from the foul amine solution thereby reactivating it. The hydrogen sulphide gas released from the amine solution leaves the tops of the extractors and is routed to the sulphur recovery unit as feed. The regenerated amine is circulated continuously back to the top of the extraction towers after heat exchange with foul amine and final cooling.

Sulphur Recovery Unit Operations

The acid gas fed to the sulphur plant contains up to 80% hydrogen sulphide which is converted to molten sulphur of 99.9+% purity in a standard two-stage converter. The acid gas stream is fed into the combustion chamber of a waste heat boiler. Air supplied by a blower is admitted to the combustion chamber and the air rate is so regulated to burn only one-third of the hydrogen sulphide in the acid gas to sulphur dioxide. The sulphur dioxide formed combines with the remaining hydrogen sulphide to form sulphur and water. Since the reactions are conducted at elevated temperatures, the products formed are in the vapour state. The reactions are represented by the following equations :-

$$H_2S + 3/2\ O_2 \longrightarrow H_2O + SO_2$$
$$2\ H_2S + SO_2 \longrightarrow 2\ H_2O + 3S$$

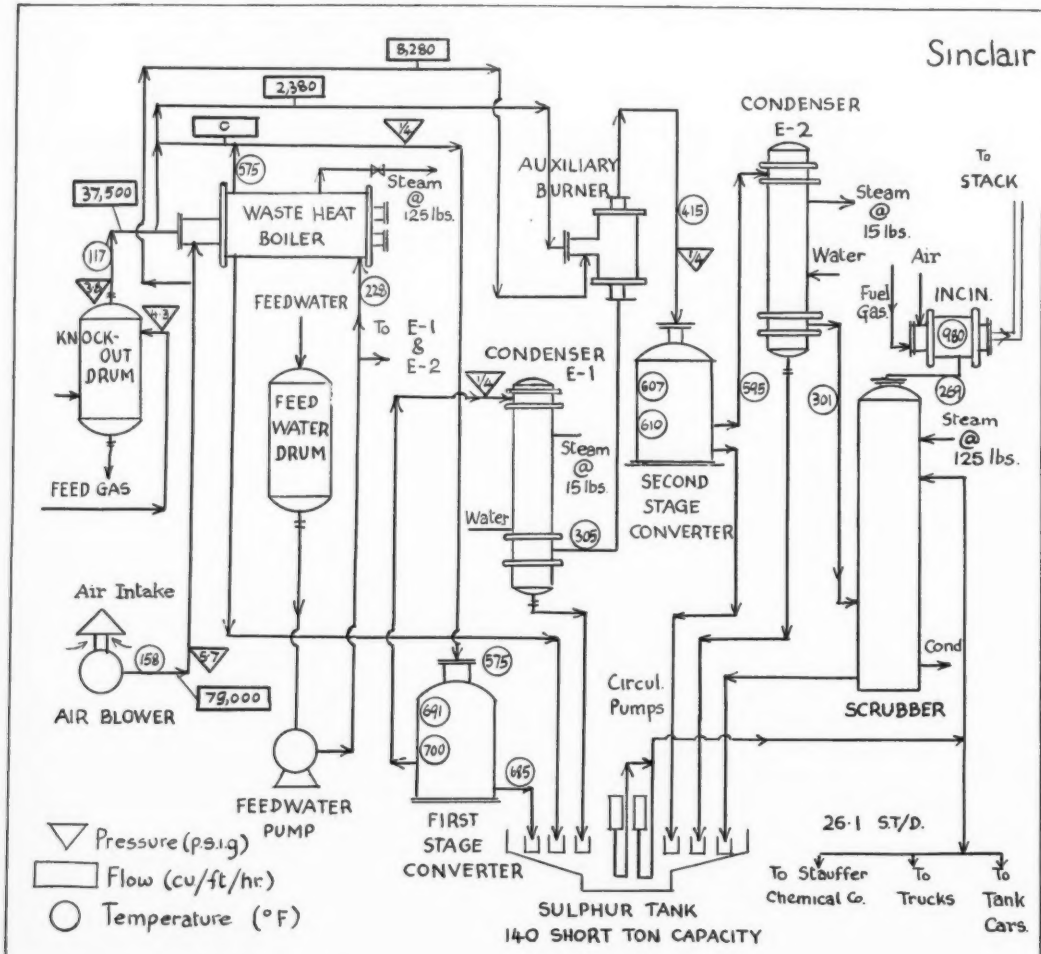
Flame temperatures as high as 1500°F have been recorded in the combustion chamber of the waste heat boiler, the elevated temperatures are a result of the heat evolved by the combustion of burning gases plus the heat liberated by the exothermic sulphur forming reactions. This combined heat is removed by the generation of 150 p.s.i.g. steam at the waste heat boiler. The sulphur forming reactions start to take place at the elevated temperatures and some of the sulphur vapours formed by the above reactions begin to condense out at the waste heat boiler and drain out as molten sulphur through a seal pot into an underground molten sulphur storage tank. The remaining vapours pass through the combustion chamber and are cooled as they pass through the reversing chamber at the rear of the boiler. The hot gases then move forward through boiler tubes and are cooled to approximately 575°F before leaving the waste heat boiler.

Exit gases from the waste heat boiler then pass downward through a bauxite bed of catalyst in the first converter. The catalyst promotes the reaction and bring it nearer completion, thereby contributing to greater sulphur recovery.

Since the reactions occurring in the first converter are exothermic, there is a temperature rise across the catalyst bed of the first converter. The sulphur leaves this vessel in the vapour state without any molten sulphur dropping out. The sulphur vapours and remaining gases are then cooled in a condenser to approximately 300°F and the sulphur vapours condense and drop out the bottom of the condenser in the molten state flowing through a seal pot into the underground molten storage tank.

The cooling of the gases and condensing of sulphur takes place within the tubes of the vertical condenser, boiler feed water is supplied to the shell of the condenser and a small quantity of steam at 15lbs per sq. in. is generated as a result of the heat exchange.

The unreacted gases which are uncondensed leave the condenser and flow into an



Sinclair Refining Company

Marcus Hook Refinery.

SULPHUR RECOVERY PLANT

Laboratory Inspection Data.

	Acid Feed Gas Mol %		Stack Gas Mol %
Hydrocarbons	1·1	O_2	1·1
CH_3SH	0·0	SO_2	1·5
H_2S	79·6	H_2S	0·0
CO_2	17·0	CO	12·6
N_2	0·2	CO_2	7·6
NH_3	2·1	N_2	77·2
	100·0		100·0

Vol. Dry Acid Gas 34,350 scf/hr.

PLANT TEST DATA

Avail. Sulphur (Calc.) 2,340 lbs/hr.
Plant Efficiency 93%

Sulphur Prod.	lbs/hr	%
Pit Guage	2,175	
Waste Ht. Boiler	582	27·1
1 Converter	0	0·0
1 Condenser	1,170	54·2
2 Converter	0	0·0
2 Condenser	240	11·4
Scrubber	160	7·3
Total	2,152	100·0

auxiliary burner. The burner is a small combustion chamber fired with a small quantity slip stream of acid gas feed to the sulphur plant and a small quantity of combustion air. The unreacted gases are reheated in this auxiliary burner to approximately 425°F and flow into the second catalytic converter where a bauxite catalyst bed promotes further reactions in the process gas stream so that an overall recovery of 93% sulphur is realized from the hydrogen sulphide contained in the acid gas feed stream to the unit. Here again the reactions are exothermic and some temperature increase is realized across the catalyst bed. Some sulphur will condense in the second converter leaving the bottom of the vessel as molten sulphur through a seal pot into the underground storage tank.

The exit gases from the second converter enter a condenser where they are cooled to approximately 300°F. Sulphur vapours condense and leave the bottom of this second condenser in the same manner as described for the first. As in the case of the first condenser, a small quantity of steam at 15lbs per sq. in. is generated in the 2nd condenser as a result of the heat removed in cooling the gases and condensing sulphur.

Exit gases from the second condenser then pass upward through a scrubber containing a bed of Raschig rings. Some molten sulphur from the underground tank is pumped down through the Raschig rings as reflux to absorb any sulphur mist that might be carried out of the unit. The recovered sulphur and sulphur reflux flow out the bottom of the scrubber as molten sulphur through a seal pot and return to the underground tank. Exit gases from the top of the scrubber flow into an incinerator which is fired with a small quantity of fuel gas and any traces of sulphur vapours or unconverted hydrogen sulphide leaving the system are burned to sulphur dioxide. All lines carrying molten sulphur are steam jacketed to maintain the sulphur in a molten state at temperatures between 280°-300°F. Steam coils in the converters, scrubber and underground storage tank are used to maintain these temperatures.

Built by the Ralph M. Parsons Company the plant came on stream in February, 1956. Molten sulphur is made available to the Stauffer Chemical Co. plant at a nearby site by means of steam jacketed lines and there are also facilities for its distribution either by rail or by road.

SULPHUR IN MEXICO

PANAMERICAN SULPHUR COMPANY

THE production on 10th December of the one millionth ton of sulphur extracted by the Frasch process from the company's Jaltipan dome prompted the company's President, *Mr. H. C. Webb*, to review the company's affairs against the background of less than two years positive operations and to look into the immediate future. The company's Mexican operating subsidiary, Azufrera Panamericana under the direction of *Mr. Harold H. Jaquet*, is confidently expected to produce in 1956 more than 600,000 tons, the third largest output of Frasch sulphur by a single company in the world.

Pan American started pilot production in September, 1954, with full scale operation getting under way in May, 1955. Originally the plant was capable of heating 3.3 million gallons of water daily, but with the expansion programme now completed, the plant's capacity has been increased to more than five million gallons daily. With the additional water, the plant is capable of producing in excess of a million tons of sulphur a year. Water ratios for current production, Mr. Webb indicated, are running slightly more than 1,000 gallons a ton of sulphur produced. At the close of 1956, Mr. Webb estimated that his firm would have stockpiled just under 500,000 tons of sulphur. It is planned, he said, to maintain an inventory of about 600,000 tons, with production geared appropriately.

With shipments in 1956 likely to exceed 400,000 tons to sulphur consumers through-

out the world, Mr. Webb foresaw a substantial increase in 1957, supported by an expansion of output to 700,000 tons. The satisfactory operation of the new filtering plant is expected to secure this output in the form of cleaned sulphur with a carbon content not exceeding 0.3%. In anticipation of greater shipments next year, construction of additional facilities is to start immediately to augment the company's present deepwater installation at Coatzacoalcos. Soil studies and design plans have already been completed.

Turning to the company's past and future role in the Mexican economy, Mr. Webb pointed out that the expenditure to date of more than 130 million pesos — or approximately $11 million — has been incurred in constructing the production and shipping facilities, exploratory costs, and the acquisition of surface rights, with more investment earmarked for the future. Based on present production, in addition to expenditure for fixed assets, the company will spend annually about 100 million pesos ($8 million) additionally; this will cover royalties, taxes, port charges, fuel, rail freight, salaries and wages, materials and supplies, and the like.

GULF SULPHUR CORPORATION

The continued satisfactory operation of the company's Las Salinas dome, where Frasch sulphur production started at the beginning of May, has been reflected by the gradual increase of production from the earlier level of 400 tons per day. The quality of output is authoritatively reported to be satisfactory and improving. Nevertheless, to enable the management to supply sulphur to any specifications, it has been decided to build a sulphur filtering plant at Coatzacoalcos. Construction work will be carried out by the Hudson Engineering Company—one of Gulf Sulphur Corporation's two parent companies—and the plant is due to be in full operation by February, 1957. Whereas at the early stages of operations the company had the use of Mexican Gulf Sulphur Company's shipping and loading facilities, its own installation at the free port area of Coatzacoalcos were completed by the Hudson Engineering Company at the end of November 1956 and were promptly taken into use to effect shipments.

Like their fellow-Frasch-sulphur producers in Mexico, the company looks to the U.S.A. for its main market. Already a long term contract has been signed with the Davison Chemical Co., one of the leading fertilizer producers and a subsidiary of Messrs. W. R. Grace and Co.; reported to be based on current prices it covers the supply of over one million tons over a ten year period. European and U.K. and Commonwealth markets were examined by *Mr. J. Oostermeyer,* Director and *Mr. J. Keene,* Vice-President—Sales, during their extensive visit to the U.K. and Europe in the early autumn.

TEXAS INTERNATIONAL SULPHUR COMPANY

In his progress report to stockholders of 26th November *Mr. Dale R. Major,* the president, gave further indications of the vigorous policy which is now being pursued by the board since the settlement in July of disputes over the control of the company. With the close of the rainy season, the drilling programme is stated to have been resumed on a full schedule after some reduction, but no cessation of operations during the preceding months. Using 5 drilling rigs, of which 3 were newly purchased, Mr. Major anticipated the completion by 1st January 1957 of all exploratory drilling work at the Texistipec concession, where earlier this year reserves of 5 million tons sulphur had been proved by the company's consultant Mr. J. B. Eby.

The next of the company's extensive concession areas to be explored in the course of a 4 months drilling programme is Nopalata, adjacent to the dome area leased by Texas Gulf Sulphur where as mentioned below the start of operations is imminent. Thereafter each of the six concession areas, on which domes are known to be situated is to be explored by drilling. The entire programme, which is to extend over 12-18 months, is expected to cost approximately $50,000 per month, funds being provided by the Syndicate under the leadership of Guarantee Trust Incorporated of Houston, financing the company's operation.

The principal item of interest in the President's progress report is that the company is negotiating with one of the most prominent plant contractors in the U.S.A. which has proposed to undertake to build the 1,000 ton

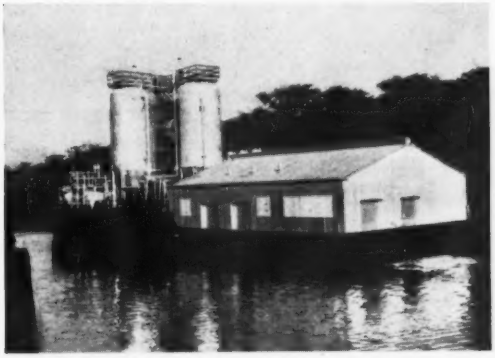
per day Frasch sulphur plant at Texistipec where, in the latter half of November, work preparatory to selecting a plant site was in progress.

TEXAS GULF SULPHUR COMPANY

The start of operation of the Santa Anita dome is now reported to have been deferred to the early New Year, the barge-mounted plant, pipe lines, pumping and metering

Barge 1 carrying boilers, water treating equipment and Laboratory.

stations and other ancillary plant having in the meantime been tested and found wholly satisfactory. In the absence of indications that the quality of the output would differ from that being produced at Mexico's two operating



Barge 2 with water softeners, filters, heaters, pumps, turbo-generators, air compressors and the control centre. The two barges make up a complete Frasch sulphur plant.

domes, Jaltipan and Las Salinas, Texas Gulf Sulphur Company is giving serious consideration to the installation of a filtering plant with a view to reducing the carbon content and improving the colour of the expected output. Another pending decision is whether the company should ship direct from Mexico to customers overseas and the U.S.A. or whether the local output should first go to the company's main storage areas and loading installations at Galveston.

Summary

Mexican Frasch sulphur production in 1956 is likely to total about 650,000 tons of which about 450,000 tons is expected to be shipped to customers in U.S.A. and in practically every other significant market in the world. The desirability of installing filtering equipment appears to be now generally accepted by the Mexican sulphur producers as it enables them to improve their competitive position. Although unable to meet the needs of those who must use bright sulphur, since none of the Mexican producers have yet gone to such lengths in off-colour sulphur cleansing as for example the Freeport Sulphur Company in U.S.A., it is now widely accepted that the quality of filtered material adequately meets most requirements, certainly those of acid manufacturers.

During the current year Mexican sulphur exports having made some inroads in the U.S. domestic markets, also took up practically the entire expansion of elemental usage elsewhere. Mounting output and the determination of all producers to attract custom by competitive quality and price may be expected to force U.S. producers to give way further in virtually all markets. The most serious setback to the industry's immediate prosperity is the present exorbitant level of freights and the dearth of shipping space, but as these extreme conditions are unlikely to persist, the development of individual companies production and sales facilities may be expected to find their proper rewards.

UNITED KINGDOM SULPHUR

CONSUMPTION of sulphur in all forms during the third quarter 1956 totalled 210,000 tons* and although 9% lower than the preceding quarter, it was 3½% greater than in the corresponding period last year. The general level of industrial production throughout this period declined seasonally and reached its lowest point in August. Similarly the production of sulphuric acid declined, but although industrial production was lower than the corresponding period last year acid production was 5½% greater. As anticipated, anhydrite sulphuric acid plants continued operating near capacity while the decline in acid production was principally felt by the users of pyrites whose consumption fell to the lowest level since the first quarter 1953 while spent oxide reached its lowest level since the fourth quarter 1952. Consumption of acid sulphur rose significantly by 10% compared with the corresponding period last year and is the highest third quarter's total on record.

Details of the consumption of the various raw materials are as follows:—

maintaining its exports in the now highly competitive foreign markets.

Of the total sulphur consumed it is estimated that 42% was met from indigenous sources (sulphur in anhydrite used for acid manufacture, spent oxide, zinc smelter gases, and recovered from coal and oil refinery gases) 20% from imported pyrites and 38% from imported brimstone.

Imports of elemental sulphur during the third quarter totalled 98,885 tons, valued at £15 1s. per ton, an increase of 12½% compared with the previous quarter, while the imports of pyrites showed an increase of 24% to 96,337 tons, valued at £8 5s. per ton.

Sulphuric Acid†

Production of sulphuric acid during the third quarter totalled 515,632 tons (100% H_2SO_4) a decrease of 7¾% compared with the previous quarter and an increase of 5½% compared with the corresponding period last year. Total effective production capacity increased by 12,500 tons during the quarter but only 73.3% of capacity was employed.

	3rd Qtr. 1956	*2nd Qtr. 1956*	*Change§ %*	*3rd Qtr. 1955*	*Change§ %*
Elemental Sulphur:					
Acid: Imported	58,200	62,400	— 6¾	54,800	+ 6¼
Recovered, H_2S and Filter Cake ...	7,500	9,600	—22	4,900	+ 53
Total "Acid" Sulphur	65,700	72,000	— 8¾	59,700	+ 10
Regular	26,100	29,000	—10	26,000	+ ½
Total Elemental Sulphur	91,800	101,000	— 9	85,700	+ 7
Pyrites	87,900	107,300	—18	104,100	—15½
Spent Oxide	56,100	63,400	—11½	56,4000	— ½
Anhydrite	172,000	169,300	+ 1½	120,400	+43
Zinc Concentrates	45,000	43,600	+ 3¾	52,400	—14

§ Percentage figures shown indicate change between earlier periods and the third quarter 1956.

Consumption of regular sulphur of 26,100 tons also seasonally low reflects the difficulties of both the car and textile industries. The car industry beset by troubles both on the home and overseas markets has been mainly responsible for reducing rubber consumption by about 20% compared with the corresponding period last year. The rayon industry has, however, not only been faced with a lower demand for high tenacity yarn for tyre manufacture, but is experiencing difficulty in

The various sulphurous raw materials were used to achieve this output in the following proportions:—

	3rd Qtr. 1956	*2nd Qtr. 1956*	*3rd Qtr. 1955*
	%	%	%
Elemental Sulphur:			
Imported Brimstone ...	31¾	31	31
Recovered, H_2S & filter cake	4	4¾	2¾
Sulphur in:			
Pyrites	22¾	25¼	28
Spent Oxide	14½	15	15¼
Zinc Concentrates ...	7¼	6½	8¾
Anhydrite	19¾	17½	14¼
Total Sulphur (000 tons)	184	201	177

* Excluding consumption of sulphur in anyhydrite for direct manufacture of sulphate of ammonia.

† We are indebted to the National Sulphuric Acid Association for information placed at our disposal.

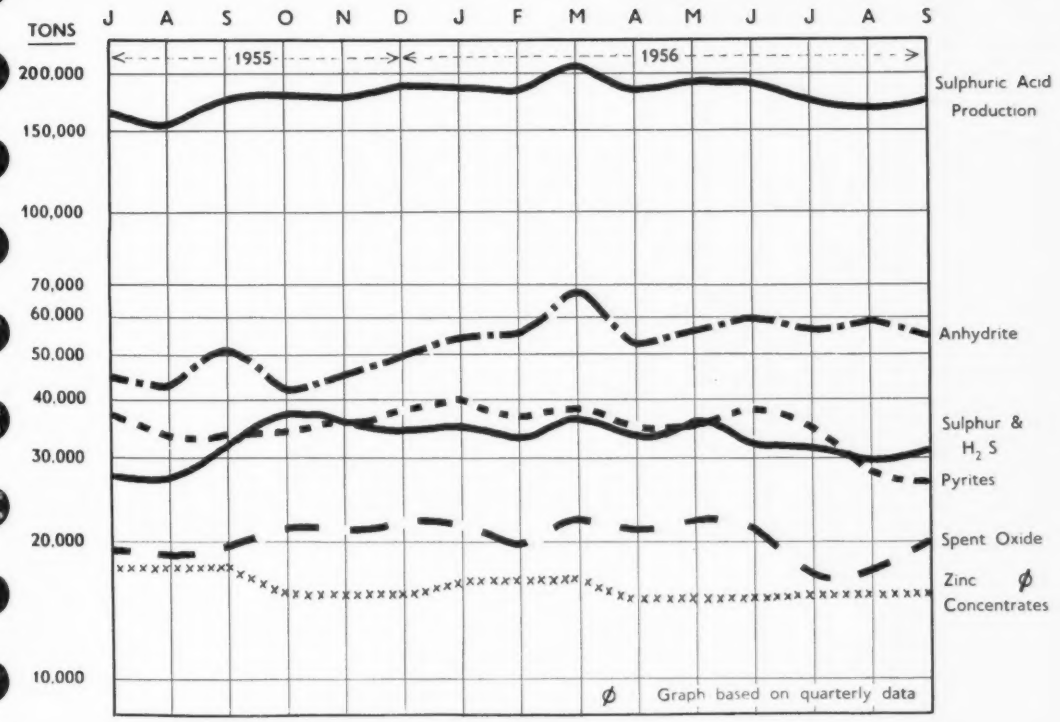


Fig. 5. Monthly Consumption of Sulphurous Raw Materials and Production of Sulphuric Acid.

During the third quarter the impact of anhydrite sulphuric acid on the supply position was more pronounced and accounted for 19½% of the total acid production compared with 17½% in the previous quarter. This was due to the lower level of acid output during the quarter, coupled with the economic necessity of operating the anhydrite plants close to capacity which resulted in a comparatively greater decline in the use of other sulphurous raw materials. The production of brimstone acid, however, although lower than in the second quarter accounted for a greater part of total acid output. It is estimated that anhydrite acid plants operated at 98% of capacity, brimstone acid plants at 70%, pyrites roasters at 56%, and spent oxide burners at about 72% of capacity.

Acid Consumption

Consumption of sulphuric acid amounted to 512,613 tons (100% H_2SO_4) representing a decrease of 8¼% compared with the preceding quarter and a rise of 4¾% over that of the third quarter for 1955.

Sulphuric acid usage by the main consumer groups in the respective periods was as follows:—

	3rd Qtr. 1956		*3rd Qtr. 1955*	
	000 tons	%	*000 tons*	%
Fertilizers	175	34.1	169	34.0
Chemicals	69	13.5	67	13.5
Titanium Dioxide and Lithopone ...	71	13.8	62	12.5
Rayon and Transparent Paper	63	12.4	59	11.9
Metallurgy	29	5.7	28	5.6
Oil Refining	15	3.0	15	3.0
Dyes	18	3.4	20	4.0
Soaps and Detergents ...	18	3.5	16	3.2
Miscellaneous ...	54	10.6	61	12.3
Total	512	100.0	497	100.0

The principal changes in individual consuming industries compared with the corresponding period in 1955 were as follows:—

	Change	
	tons	%
Titanium Dioxide	+ 9,400	16¼
Rayon and Transparent Paper ...	+ 4,000	6¾
Superphosphates	+ 3,900	3¾
Soap, Glycerine and Detergents...	+ 2,100	13
Dyestuffs and Intermediates ...	— 2,900	14¼
Explosives	— 2,900	48

Quantitively smaller, but nevertheless important changes occurred in sulphuric acid used for agricultural purposes (+71%), drugs and fine chemicals (−13½%), vegetable oils (−21%), sulphate of copper, nickel, etc. (+37%).

The iron and steel industry did not to any extent feel the effects of the car strike in August, and the credit squeeze has not hampered unduly the high level of demand for steel. Agricultural demand remained the corner-stone of the acid industry and accounts for over one-third of consumption. Titanium dioxide shows an important rise compared with last year, although the level of consumption achieved this year has remained constant. The present cycle of expansion in the titanium dioxide industry is now complete and new plans and programmes are imminent for a further round of expansions.

Summary

Significant developments in the U.K. Sulphur industry in the third quarter, 1956, are as follows:—

(i) The production of anhydrite sulphuric acid, which is now maintained at a high level throughout the year, has been fully absorbed by British Industry.

(ii) Continued abundant supplies of brimstone have re-established its preferential use especially vis-à-vis pyrites.

(iii) During the first nine months of this year sulphuric acid has been produced at an annual rate of 2.23 million tons, 9% more than last year's record production.

The sulphur industry as a whole remained buoyant during the quarter, and reflects the present stability of the heavy and agricultural industries. The effect of the Suez crisis in the form of the unprecedented rise in freight rates, even compared with the Korean War, is not likely to be reflected on sulphur imports during the last quarter of the year. Its effects on inland transport, however, cannot fail to reduce the volume of acid movement and thereby curtail the level of activity of the sulphur industry at a time of year when it is normally high.

SULPHUR IN ITALY

DURING the three months' period ending 30th November, 1956, production of refined sulphur in Italy amounted to 60,681 metric tons, representing a decrease of 5,623 metric tons (8½%) compared with the corresponding period in 1955. It is significant that at the same time the production of sulphur ore has increased substantially to meet the expanding needs of the sulphuric acid industry. A further increase in the consumption of low-grade sulphur ore for the direct use in the manufacture of sulphuric acid is foreseen, since the price of this material is highly competitive with the cost of sulphur in pyrites. This change in the pattern of sulphur consumption is a welcome development, as it may help to counteract the upward trend in pyrites imports, whilst at the same time broadening the base of the native sulphur industry.

Deliveries of fused sulphur during the three months' period under review totalled 85,447 metric tons, 33% more than during the corresponding period last year. The increase was wholly due to the rise in exports, whilst domestic sales declined slightly.

Deliveries		*August to November* 1955	1956	*Change* %
		metric tons		
Domestic	...	36,238	34,070	— 6½
Exports*	...	20,533	51,377	+60
Total	...	56,771	85,447	+33½

The excess of deliveries over current production enabled Ente Zolfi Italiani further to reduce the stock pile, which at the end of November amounted to 285,753 metric tons. At this level, stocks are 62,243 metric tons (18%) lower than one year ago. The decline is principally attributable to the financial support given to the industry by the Government in the form of subsidies, which have enabled Italy to re-enter successfully albeit selectively into world sulphur trade.

* For details of 1955/6 exports see Statistical Appendix.

The Avenue Carbonisation and Chemical Plant

General

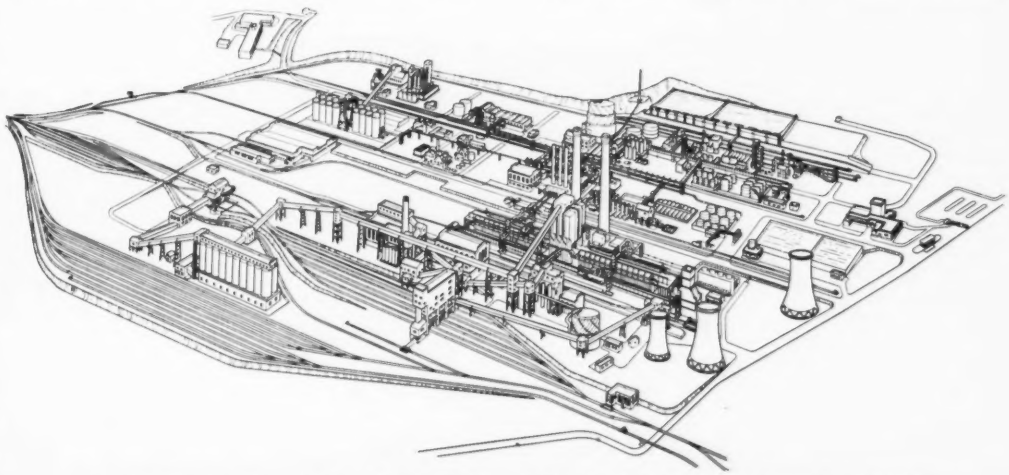
ONE of the most up-to-date in the world, the Avenue Carbonisation Plant comprises a series of integrated installations which are scientifically designed to make the fullest possible use of relatively low ranking coals from which coke, purified gas suitable for town supply, a whole range of coal and other chemicals and also electric power are derived. Production of coke as a smokeless fuel can be adapted, if required, to the production of metallurgical coke. The plant occupies a 188-acre site at Wingerworth, Chesterfield, having been built for the National Coal Board East Midlands Division over a four-year period at a cost of £10 million by Messrs. Woodall-Duckham Construction Co. Ltd., Babcock & Wilcox Ltd., Newton Chambers & Co. Ltd., Chemical Engineering Wiltons, Ltd. and Simon-Carves Ltd. as principal contractors. It is completely self-contained and apart from coal only small amounts of lime and soda need to be brought in; the plant will, however, receive supplies of benzole, tar and spent oxide from nearby Grassmore, Hardwick and Harworth coke ovens which, the National Coal Board decided, would thus be used more efficiently. The Avenue Plant carbonising—at full capacity—2,175 tons coal per day yields 1,400 tons coke and 27 million cu. ft. of crude gas. The ancillary plants, however, supplemented as indicated above, treat by-products derived from over 4,500 tons coal daily. Also the entire outfall of surplus coke-breeze is being fired under boilers giving steam for electricity generation and works use.

Most of the coal treated in Wingerworth and at the dependent coke-oven plants are " medium-sulphur coals " probably between 1.5 and 2% sulphur. Dry purification of crude gas yields some 18 tons sulphur a day in the form of about 40 tons spent ferric oxide of good quality (46-48% S). A notable feature of the sulphuric acid plant is the novel combination of Flixborough rotary burners and Kachkaroff nitration towers, both relatively untried installations; the burners developed by Nitrogen Fertilizers Limited were designed to give high SO_2 concentrations for use in a contact convertor while the only other Kachkaroff plant, at Phoenix Wharf, Greenwich, is served by Harris furnaces.

Mechanisation of the purification installations together with on-site regeneration of the purification mass should result in an exceptionally favourable cost of sulphuric acid produced from this coal by-product.

Carbonisation

The carbonisation unit, the nucleus of the operations, is using the lower rank coals from



General Plan of Avenue Plant. Tower Purifiers, Sulphuric Acid Unit and Ammonium Sulphate Plant left background.

Diagram by courtesy of Woodall Duckham Construction Co. Ltd.

local colleries, and will have a capacity to treat about 750,000 tons coal annually. The coke ovens consist of two batteries each containing 53 Woodall-Duckham Becker combination underjet units each with a carbonizing capacity of 15 tons in 16 hours. Employing the latest methods for blending the coal, utilization of heat, and firing and discharging the coke ovens, the plant in full operation has a capacity to produce 27 million cubic feet of gas per day all of which is cleaned. Of this total 14 million are fed to the town gas system and the remainder being used to fire the oven heating flues.

Gas Cleaning

The crude gas is collected from the ovens in gas mains which run down both sides of the coke batteries and is passed to the primary cooling exhausters and tar extractors in two

Ferric Oxide Tower Purifiers.
Photo by courtesy of Newton Chambers and Co. Ltd.

separate streams for the production of ammonia liquor by the indirect process and tar. The gas stream is first cooled for the production of ammonia liquor and after the extraction of the tar in the electro-detarrers is passed to the napthalene washers. In order to obtain gas with the requisite heat value (480 B.Th. U's p.c.f.) the gas is mixed with producer gas from the gas producer plant which is then ready for purification before transfer to storage holders and/or use for firing the coke ovens.

Consisting of two sets of six welded steel towers the dry purification plant is capable of purifying 27 million cu. ft. of gas per day. The gas enters the base of these towers and is cleaned by passing through layers of hydrated oxide of iron thus removing the H_2S to the prescribed statutory units. The entire gas stream, including that fed back to boilers, is so treated and the H_2S content is reduced from 7-10 grains per cu. ft. to $\frac{1}{2}$ p.p.m. Features of this tower purification system are the ease with which each tower can be taken out of service for recharging which is performed by replacing fresh containers with oxide, while partly spent material is passed to a disintegrator for reducing to a suitable size and for eventual re-use.

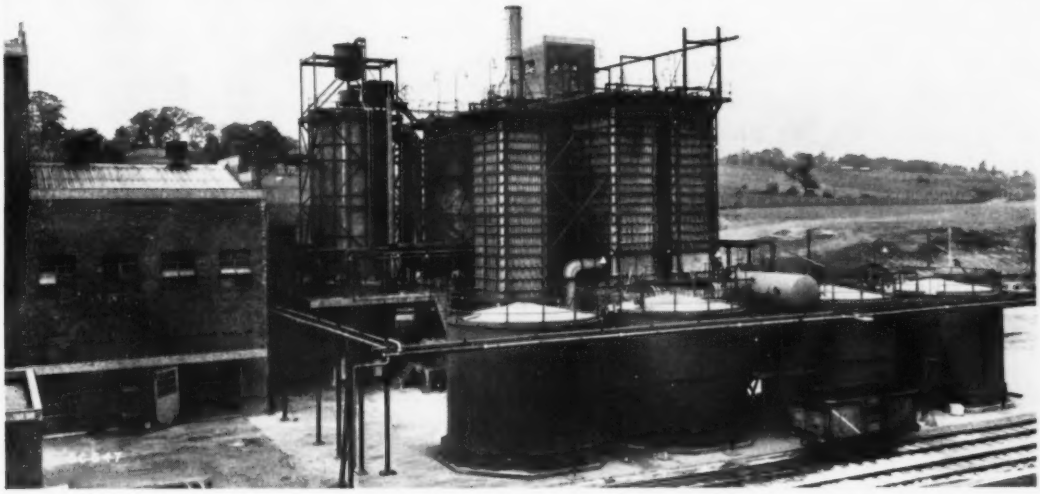
Sulphuric Acid Plant

This unit is similar to the Kachkaroff acid plant recently installed at the South Eastern Gas Board Works at Phoenix Wharf. The principal difference is, however, the recovery of the residue from the burning of the spent oxide which when mixed with sawdust and peat is suitable for recharging in the purification tower. Spent oxide is used not only from the Avenue works but also from the Board's other works. The two Flixborough rotary burners are designed for use with spent oxide containing 46-48% sulphur and after ignition the furnace gases averaging 5-6% SO_2 are collected, cleaned and boosted to the Kachkaroff acid plant while the oxide and cinder pass down the bunker for discharge and treatment. The plant, which has a capacity to produce 50 tons per day (100% H_2SO_4), is fully instrumented and incorporates the latest developments in heat exchangers and a wide range of building materials due to high nitrosities and varying concentrations of acid in circulation. An interesting feature is the use of various types of P.V.C. materials for pipework, tanks and tower sheathings where low temperatures are encountered, thus helping to reduce corrosion and improve overall efficiency.

Sulphate of Ammonia Plant

With a capacity to treat 7,000 gallons per hour of ammonia liquor the plant will be capable of producing about 45 tons per day of ammonium sulphate. There are two ammonia stills, one of which is a stand-by, incorporating Limbux liming equipment while the Royston ammonia saturators are designed to produce a large crystal salt. After the excess liquor has been drained off the wet crystal sulphate is initially centrifugally dried and followed by flash drying which incorporates a

device to neutralise the acidity of the sulphate. There are facilities for automatic bagging and the storing of 1,500 tons of suphate.



Kachkaroff Sulphuric Acid Unit: Nitration Towers.

Conclusion

The principle of establishing a major coke, gas and by-products plant using low-grade coals near the pithead may well represent the end of a long period of separate developments of the coke oven and town gas industries of the United Kingdom. The envisaged establishment in each National Coal Board region of one or more major installations on the lines of the Avenue plant would give the industry the means of making the best possible fuel and chemicals use of coal resources which qualitatively are now on the decline coupled with obvious transportation economies. From the point of view of sulphur recovery these developments offer great scope not only in their contribution to cleaner air but as important sources of indigenous sulphur supplies. Although at the Avenue plant advantage has been taken of novel developments in the use of spent oxide for acid manufacture, large gas-making units such as these are ideal media for the application of wet purification plant, which yields sulphur in a more attractive form and probably also more economically.

Sulphur Extraction and Recovery from Coal Gas

Coppée Process

FOR many years it has been the proud boast of the coal carbonisation industry in the United Kingdom that its practice of sulphur removal from coal gas, by means of ferric oxide, results in the supply to the sulphuric acid industry of a sulphurous raw material on a scale not equalled in any other country. This irrefutable claim does not dwell on the cost of this operation which, representing a substantial charge against gas production, is the price of conforming to the exacting limitation of H_2S content of town gas of $1\frac{1}{2}$ parts per million. This figure, when first imposed, is believed to have been determined not so much by the

absolute needs of the public health as by the original efficiency of the dry ferric oxide purification method and the need to give town gas its characteristic smell. Its retention has impeded the application of alternative purification methods since the inevitable need to employ spent oxide purification to remove all but the last traces of H_2S, as demanded by law, reduces the economic attractions of wet purification processes capable of removing only 75-95% of the sulphur content of the gas.

In contrast, the other branch of the carbonisation industry—the coke ovens—has not suffered under statutory regulations and in consequence the introduction of any form of sulphur removal has been sporadic. The need to make better use of coal by-products, together with the mounting volume of gas purchased by the town gas works from the coke ovens, has in recent years narrowed the earlier differences of interests and operating practice.

On the Continent this common approach to the problem is more marked. Such regulations, covering sulphur removal, as are imposed apply equally to both branches of the industry and are less exacting than those in the United Kingdom. Thus the incentive to improve the economics of sulphur removal has in recent years, not only focussed increasing attention on this aspect of the industry but also led to the development and installation of a number of wet purification processes. Although unable to achieve the comprehensive performance of the dry method, they remove sulphur in the form of H_2S which can be recovered as sulphuric acid or elemental sulphur, and so offer a more remunerative product than spent ferric oxide. The economics of sulphur recovery will inevitably vary since they depend on the type and size of the carbonising plant, on the sulphur content of the gas, on the market for the recovered sulphur product and above all on the cost of plant and operations of the sulphur removal process. On the basis of recent years' experience, the view is now widely held that equilibrium processes using ammonia as the washing medium are probably the most promising. Amongst them is the Coppée process which by virtue of several process features claims particular ease of operation, simplicity of plant and therefore overriding economic advantages over a wide range of coal carbonisation plants. Indicative data are reproduced from the O.E.E.C. Survey of Sulphur Recovery published in 1953.

Costs and investment for different recovery processes used in Germany are compared on the basis of a capacity of 500,000 cu. m. per day and a concentration of 8 grs. of H_2S per cu. m. ($17\frac{3}{4}$ million cu. ft. gas—350 grains H_2S per 100 cu. ft.).

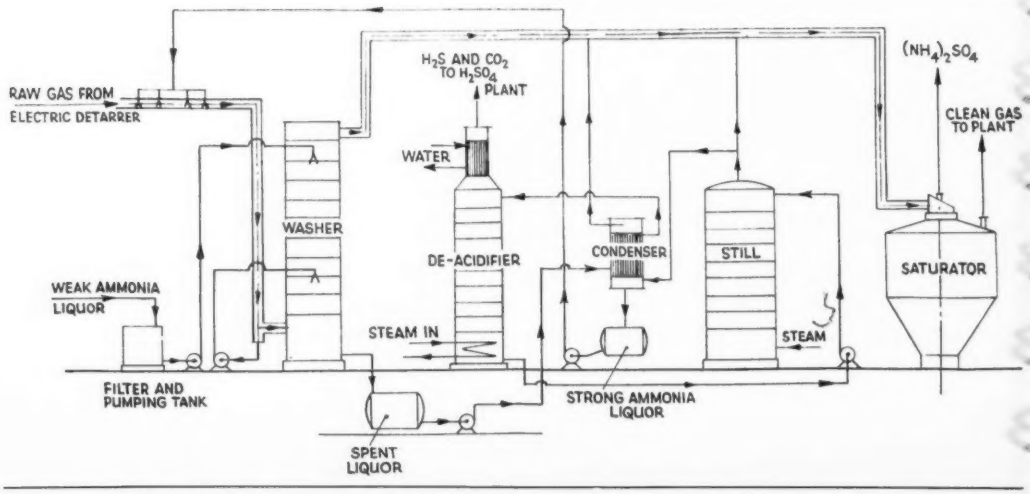


Fig. 6. Flow Diagram of Wet Purification by Semi-Direct System of Ammonia Recovery.

Process	*Absorption of H_2S*	*Extraction or conversion*	*Total*	*Investment*
		US $		
Dry Purification:				
Tower (min.)	63.5	29	92.50	475,000
(max.)	82	44	126.00	800,000
Wet Purification:				
Perox			136.50	400,000
Ammonia	26.50	14	40.50	185,000
Potash	89.50	10	99.50	490,000

Ammonia Process

Available at all carbonisation plants, ammonia liquor was long known for its ability to wash out H_2S. Earlier attempts to make use of this phenomenon failed because it was found impossible to separate H_2S without at the same time absorbing CO_2, which in turn caused low recovery of H_2S. The answer was found in 1935 by two German chemical engineers, Bähr and Braus, who by keeping the contact time between the gas and the washing medium very short, achieved preferential absorption of H_2S to CO_2. The principle was patented in 1938 by I.G. Farbenindustrie and after the war when the patent was made generally available a number of plant manufacturers and engineers adopted it and adapted it in the light of their own experience.

Absorption and desorption of H_2S by ammonia washing was discussed in considerable detail at the Sulphur Study Conference of the Institute of Fuel in London in October 1954. It emerged that although theoretical knowledge was not yet complete it was possible to build industrial plants permitting recoveries as high as 85% of the H_2S. Indeed by then some 18 plants were operating in Western Germany and one was on the point of completion in the United Kingdom*. The Coppée Company (Great Britain) Ltd., and its associates had developed their own plant and processes from these early beginnings and this, at moderate capital cost, permits the extraction of H_2S and its economic conversion to sulphuric acid or to elemental sulphur. Promising profitable operation in the case of coke ovens where stringent desulphurisation is not essential, the Coppée plant and process also offers favourable results in town gas cleaning where residual amounts of sulphur have to be removed by the conventional ferric oxide process.

The Coppée Process

The flow diagrams (fig. 6) shows schematically wet purification by semi-direct method of ammonia recovery, which is that most commonly found at United Kingdom coke oven plants. If the indirect method of NH_3 recovery is practised (fig. 7) as at all town gas works the flow and conversion to this method often results in more advantageous all-round operations and H_2S extraction is much simpler. One of the salient features of the Coppée process is the use of strong ammonia liquor as washing medium; this enables the quantity of circulating liquor to be reduced to a minimum with resultant operating economies. In common with other ammonia processes it offers

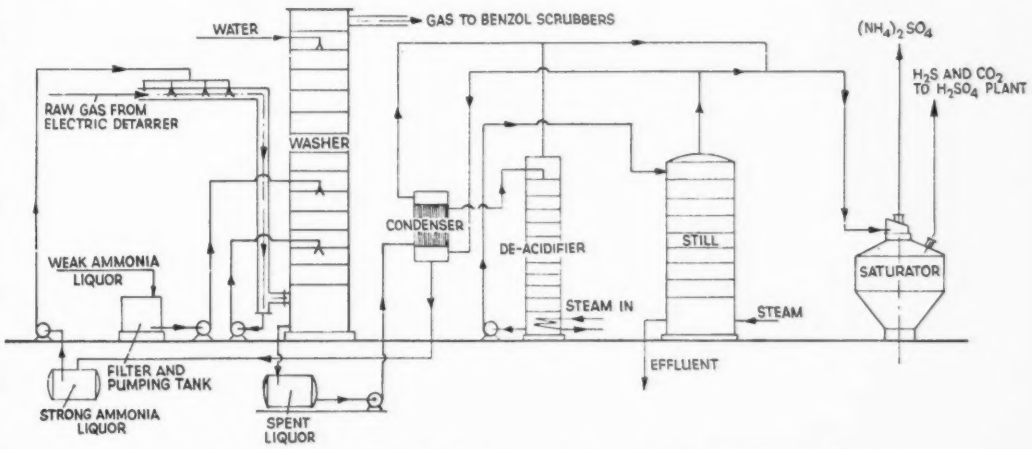


Fig. 7. Flow Diagram of Wet Purification by Indirect System of Ammonia Recovery.

* See Quarterly Bulletin No. 9 p. 21.

the best results at a gas temperature of about 20°C.

The principle of operation is similar in both indirect and semi-direct cases for H_2S absorption. Weak liquor from plant condensates is pumped into the higher part of the tower, while stronger liquor is pumped into the lower sections, or into the inlet gas main to the washer. The amount of strong liquor circulated is such as is necessary to provide the correct $NH_3 : H_2S$ ratio. In the indirect system of ammonia recovery an ammonia washing tower is superimposed over the H_2S washer.

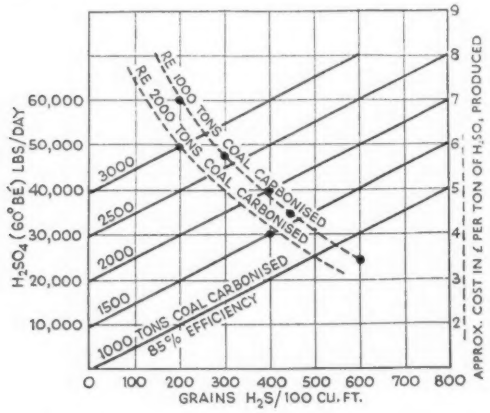


Fig. 8. Approximate Prices of H_2SO_4 in relation to the amount of gas and H_2S.

The strong liquor for re-cycling is obtained from ammonia still vapours condensate. The liquor from the washer is passed via a heat exchanger/condenser to the de-acidifying tower, where at a controlled temperature, the H_2S, CO_2 and some ammonia is driven off. These vapours join the still vapours to the saturator.

In the case of the semi-direct system the $H_2S : CO_2$ vapours, free from ammonia, go direct to the sulphuric acid plant. The gases from the de-acidifier consist mainly of a mixture of hydrogen sulphide 60 to 65 per cent, carbondioxide 30 to 35 per cent, and a small quantity of hydrocyanic acid, up to 5 per cent. These gases are burned to produce sulphuric acid or elemental sulphur. To prevent the formation of nitrogen oxides, HCN may either be recovered or completely burned under carefully controlled temperature conditions.

Wet contact sulphuric acid plants with a small daily output of 10 tons of 60° Bé (7.8 tons 100% H_2SO_4) or a Claus kiln producing only 3 tons of pure sulphur are said to show favourable process results.

Economics of Process

Owing to the divergence of conditions at individual coke oven plants, as indicated above, actual returns will vary between wide limits. The following details refer to sulphuric acid production under favourable conditions.

A. Technical Data

Gas to be treated	Coke oven gas
Quantity	24,500,000 cu. ft. per day
H_2S content in gas	630 grains per 100 cu. ft.
NH_3 content in gas	430 grains per 100 cu. ft.

B. Production

H_2SO_4 60° Bé (78/79%)	30 tons per day
Steam at 175 lb. pressure	33 tons per day

C. Production Costs Per Day

	£	s.	d.
Capital charges, depreciation and interest	52	7	2
Maintenance		1	2
Electric power, 2.975/K Wh at 1.2d. ...	14	17	6
Steam, 14.4 tons at 7/8d. ... ... (8lb./sq. inch. Additional to that produced by the process.)	5	1	5
Cooling water, 652,000 at 5d. per 1,000	13	11	8
Boiler feed water, 33 tons at 6d. ...		16	6
Operation labour, 48 man hours at 4s.	8	12	0
	£95	7	5

Thus, cost per ton of H_2SO_4 (60°Bé) = £3 3 7d.

At other coke oven installations where careful cost estimates applying to Coppée process have been carried out the following returns may be expected.

Production costs, which include provision for maintenance, amortisation, etc., should be compared with cost of acid, at present bought-in, for ammonium sulphate manufacture. This is said to vary from £6 to £10 per ton 60°Bé acid.

Quantity of gas. Million cu. ft. per day	*Grains H_2S per 100 cu. ft.*	*Tons of H_2SO_4 (60Be) produced per day*	*Production cost per ton of H_2SO_4*
14.8	275	8	£6 11 4
11.3	400	8.7	£4 0 1
33.0	750	48	£1 15 3
24.5	630	30	£3 12 10

A similar calculation for a smaller plant incorporating a Claus kiln with a capacity of 5 tons per day sulphur shows the following returns :

Capital cost:

Amortisation, interest and maintenance 15%				£22 12 0
Running costs:	£	s.	d.	
Electric power ...	1	15	0	
Cooling water ...		7	0	
Feed water		8	0	
Steam	self sufficient			
Labour 48 man hours 7 men / week ...	13	15	0	
	£16	5	0	
Total costs:				£38 17 0
Production cost:				
5 tons of S_2	£38	17	0=P/t	£ 7 15 0

At town gas works in the United Kingdom the additional capital and operating costs of ferric oxide boxes or towers inevitably reduce profitability. This disability can, however, be overcome at established works undergoing a major expansion of gas making capacity. The installation of wet purification equipment to deal with the bulk of the sulphur content offers a high return and entails no greater capital expenditure than would be incurred by increasing the dry purification plant capacity. At the same time the available ferric oxide installation will be adequate to deal with the increased, though less sulphurous gas throughput.

Conclusion

After making all allowances for adverse conditions in the United Kingdom, the slow response of the carbonisation industry to the overt advantages of wet purifiication in general, give the impression of lack of initiative. Developments as young as these, need not only enterprising industry as a proving ground, but also the full support of the manufacturers of carbonisation plants. At present sulphur removal by wet purification is practiced at only one coke oven plant and at town gas works the first up-to-date process will not be operating until 1958. This is in contrast to the practice in Germany where wet purification is not only widely used but is now standard equipment incorporated in new plants. Now that the U.K. gas industry is showing a desire to apply the new processes to their operations the weaknesses which have hitherto acted as a deterrent may be resolved. Of all coal users the carbonisation industry contributes least to air pollution but it offers ready means of augmenting domestic sulphur supplies. In the United Kingdom about 55 million tons of coal are carbonised annually, containing perhaps $1\frac{1}{4}\%$ sulphur, which is less than the national average of over $1\frac{1}{2}\%$, because coke ovens use, as far as possible, low-sulphur coals. About two thirds of the sulphur remains in the coke and only about 25-30% enters the crude gas giving a total of some 250,000 tons sulphur that could be recovered; in fact, almost exclusively in the form of spent oxide, only 140,000 tons is recovered each year. Gas made from fuel oil, which often contains more than 6% of sulphur, is of growing importance, and the underground gasification trials, due to start soon at Newman Spinney point to a vast field of application of sulphur recovery by wet purification. The Coppée process, no less than other wet purification processes, which under varying conditions may be more or less economical to instal or operate, presents a challenge to coke oven operators in the private and the publicly owned sectors of the industry and also to the nationalised town gas undertakings in the United Kingdom.

We are indebted to the Coppée Co. (G.B.) Ltd., for information and diagrams placed at our disposal.

Fluidised Bed CS_2 Manufacture

UNDER the impetus of the rapid growth of the man-made fibre industry, the production and use of carbon disulphide has expanded spectacularly over the past 30 years. The method of production, however, has remained virtually unchanged and the old-established reaction of sulphur and charcoal in retorts today still accounts for the bulk of world production estimated to total about 900,000 tons per annum.

Notwithstanding many structural changes, the thermo-dynamic limitations on the size of retorts, have prevented any significant improvement in operating efficiency since the early thirties. A further adverse factor, from the point of view of cost has been the need to use expensive wood charcoal, as a source of carbon.

The development by Food Machinery Corporation in the U.S.A. of a CS_2 manufacturing process based on the use of a gaseous hydrocarbon, in the form of methane, and

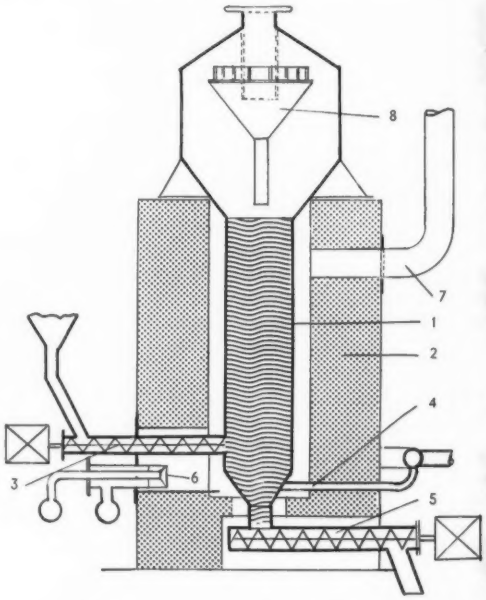
liquid sulphur represents an original and—proved by its rapidly growing application in the U.S.A. and the interest shown in Western Europe and Italy—highly successful innovation offering greater economy and efficiency of production. In the classical retort process economies were at first sought by the use of cheaper sources of carbon, such as lignite low carbonaceous coke, Brikozit in Eastern Germany and peat coke in Western Germany. The main disadvantages of using the cheaper Brikozit, at 1/10th to 1/15th of the cost of charcoal, and of peat coke,* at about 1/7th of the cost of charcoal, are slag formation and retort cleaning difficulties. In his attempt to overcome these troubles Hubert Sperling of Wittenberge in Eastern Germany adopted fluidised bed conditions and successfully developed a plant and process. Based on the same principle, the Standard Oil Corporation in the U.S.A. is also stated to have developed in recent years a plant and process for the manufacture of CS_2 but it is not known whether this has found industrial application.

The Process

The carbonaceous material — charcoal, peat coke or low temperature coke—is dried and preheated to glowing point by retort gases and is thus activated. By means of a worm conveyor it is fed—batchwise or continuously—to the retort into which some of the inert furnace exit gases are blown to fluidise the bed. Sulphur is vaporised at a temperature of 850° to 900°C when it is in the S_2 form. Its vapour pressure is then so high that it will penetrate the fluidised layer, the pressure being maintained by a steady supply of liquid sulphur to the retort. The rapid heat transfer from the retort walls to the homogeneous fluidised bed permits formation of CS_2 during the short time of residence of sulphur in the bed.

Retort and vapouriser are heated externally. The fluidisation gas shows an analysis of 0.2% O_2, 0.8% C, 19.9% CO_2 and 79.0% N_2. The oxygen content reacts with S_2 to form SO_2, whereby the resultant heat of the reaction is contributory to the main process.

The CS_2 in vapour form leaves the retort by way of a cyclone, the stripped solids being returned to process. The CS_2 is then countercurrent washed with liquid sulphur which removes un-reacted sulphur and any remaining solids. It is condensed and the H_2S content is reconverted to elemental sulphur in a Claus kiln. Ash, which owing to its greater specific gravity sinks through the fluidised bed, is discharged batchwise or continuously through a worm conveyor. Gas pressure and volume instrumentation control the reaction.



1	Retort	5	Ash Worm Conveyor
2	Preheater	6	Burner
3	Carbon Wormfeed	7	Smoke Vent
4	Sulphur Vapour Line	8	Cyclone

Fig. 9.

The conversion factor of the classical retort is about 1kg. CS_2 per hour/cubic metre, whereas fluidised bed process shows factors of 2.3-9.8 kg.CS_2 per hour/cubic metre, with an average of 5 kg. Thus the efficiency of the new process is five times that of the old and by careful adjustment in order to achieve the most favourable thermo-dynamic conditions it is possible over a long period to achieve a ten-fold increase of efficiency. However, it is understood that the fluidised bed should be homogeneous and dynamic disturb-

* 75-85% C, 5-3% Ash, point of ignition 200-250° C.
(1) 6½lbs. CS_2 per hour/100 cubic feet.
(2) 14¼-61¼lbs. CS_2 per hour/100 cubic feet.

ances can cause efficiency to drop so that it is no more than twice that of the chemical process.

It appears that in Eastern Germany this process is now employed, based on the use of charcoal and low temperature coke. In the case of the later, which on account of lower prime cost appears to be gaining favour, it is of interest to note that the site of the CS_2 manufacturing plant is recommended to be alongside coke ovens or a section of the lignite carbonising and by-product plants and not, as has been conventional to date, at the man-made fibre factory, since the use at source of activated carbon in the form of red hot coke further contributes to efficiency.

Conclusion

Although the application of the fluidised bed principle to carbon disulphide manufacture entails more complex plant than that used by the classical retort method it offers a wide choice of carbonaceous material and above all promises substantial savings in operating costs. Especially where large scale manufacture takes place, the possibility of using larger retorts, resulting in greater efficiency, is claimed to offer over-riding advantages. There is little doubt that the alternative new process based on the use of methane and liquid sulphur is simpler, cleaner and probably also a cheaper method of production, but it depends on the availability of low cost supplies of pure methane. In the United Kingdom and most Western European countries solid carbons are with few exceptions likely to be more readily available, and under these conditions the new fluidised bed process, once its reliability and flexibility at various levels of production have been proved, may be expected to find increasing application. It is, however, not known whether the substantially lower processing costs justify the undoubtedly higher capital outlay involved.

This account is based on a Review by Herr Hubert Sperling in "Chemische Technik"—July, 1956.

CURRENT EVENTS

Sulphur Production and Consumption

UNITED KINGDOM

Chemical Construction (Great Britain) Ltd.

Following the transfer last April of Chemical Construction Corporation, the subsidiary of the American Cyanamid Company of New York, to the Electric Bond & Share Company a similar change of ownership has been completed in London early in December. The Engineering Department of the American-owned Cyanamid Products Ltd. of London has been absorbed by the newly-formed *Chemical Construction (Great Britain) Ltd.*, which represents the United Kingdom interest of the above-named American principals. The Managing Director of the new company is *Mr. Michael S. Henderson*, former Director of Cyanamid Products Ltd. The new company has taken over the engineering staff of the former concern, which has 20 years experience of plant construction throughout the Sterling area. The U.S. parent company's world-wide construction activities account for, amongst others, 29% of the world synthetic ammonia production capacity and 35% of the world's sulphuric acid capacity.

AUSTRALIA

Sulphuric Acid for Uranium Leaching

Mary Kathleen Uranium Ltd. has recently placed contracts for the construction of their uranium oxide treatment plant. The sulphuric acid plant, which is to be built by Simon-Carves Ltd., will have a capacity of 110 tons per day and will use imported elemental sulphur.

Jointly owned by Rio Tinto Ltd. (56%), Australasian Oil Exploration Ltd. (35%) and the original owners (9%), Mary Kathleen Uranium Ltd. have already contracted to sell uranium oxide to the value of £37½ million. The drilling programme has now been determined and the ore treatment plant is scheduled for production in March 1959.

CANADA

Sulphur Recovery Plant

Utilizing hydrogen sulphide arising at five oil refineries in Montreal, the *Laurentide Chemical and Sulphur Company* has under construction a plant capable of extracting 33,000 tons per annum elemental sulphur from the refinery gases.

The plant, which will cost $1\frac{1}{4}$ million, is being financed by private Canadian and U.S. interests and will be Canada's first chemical plant to manufacture elemental sulphur from oil refinery gases. It is anticipated that the new plant will enter operation in June 1957 and the sulphur will be sold principally to the pulp and paper producers in the Montreal area.

Expansion at Copper Cliff

Canadian Industries Ltd. plans to construct a new sulphuric acid plant at Copper Cliff, near Sudbury (Ontario) at a cost of about $3 million. Similar to the existing plant which uses sulphur in the nickel smelter gases piped from the adjacent works of the International Nickel Company, the new installation will have a daily acid capacity of 300 tons (100% H_2SO_4). Its completion in December 1957 is to coincide with the start of mining operations by the Stanrock and Stanleigh Uranium Mines where dilute sulphuric acid will be required for uranium oxide leaching.

PAKISTAN

Sui Natural Gas

Whereas the current flow of natural gas from Sui to Karachi is only at the rate of 25 million cubic feet per day (N.T.P.) the impact of this new source of cheap fuel energy and a chemical raw material forms a basic part of Pakistan's chemical industrial development in the next five year plan.

The proved gas reserves at Sui are stated to be capable of supplying 100 million cu. ft. of gas for a period of 60 years and the present stage of development represents only one aspect of natural gas usage, mainly as a fuel. Before cleaning the analysis of the gas is as follows :—

Hydrogen Sulphide and Mercapton Sulphur	0.15
Carbon Dioxide	7.35
Nitrogen	2.46
Methane	88.52
Ethane	0.89
Other	0.63

H_2S and CO_2 are removed in a monoethanolamine unit and a dehydration unit and the gases are then discharged from the reactivator to the atmosphere without burning. At present the current level of gas cleaning does not warrant the installation of a sulphur recovery unit, although if the gas deliveries were raised to the designed level there would be an arising of about 2,000 tons elemental sulphur annually which would make Pakistan self-sufficient.

Plans for the greater utilization of gas are going forward and the Sui Gas Transmission Co. have under construction a pipeline through Multan to Lahore. It is also planned to build a nitrogen fertilizer plant which will use Sui gas and which will have an annual capacity of 100,000 tons.

UNITED STATES

Mr. John Hay Whitney

Recently appointed by President Eisenhower to represent the U.S.A. as Ambassador at the Court of St. James, Mr. J. H. Whitney is closely associated with world sulphur industry in his capacity as Chairman of the Freeport Sulphur Company. The company is the oldest American sulphur producer and its output has for long been the second largest in the world. At the present time the company is engaged in an ambitious programme of development both on land and off-shore. The new sulphur domes give promise of substantial increases in capacity and production which may well result in establishing Freeport Sulphur Company as the world's largest producer. Mr. Whitney, who served with distinction in the U.S. Air Force in World War II, is not only well known in the field of industry but also in Government, philanthropic and sports circles. His Governmental appointments have included membership of the Commission on U.S. Foreign Economic Policy, the Business Advisory Council of the U.S. Department of Commerce and the New York State Banking Board.

New Sulphuric Acid Plant in Operation at Newark

Dixon Chemical & Research Inc. started operations in November 1956 of one of the most modern sulphuric acid installations in the United States. Located on the Passaic River inlet of Newark Bay the plant, built at a cost

of $2\frac{1}{2}$ million, has a daily rated capacity of 400 tons and a maximum capacity of 450 tons (100% H_2SO_4). Ideally situated in relation to one of the most important chemical markets in the U.S.A., the new plant is producing acid of varying strengths for local distribution by barge, rail car and truck. Practically every type of sulphuric acid consumer is represented in New Jersey where approximately 10% of the national acid use, of 15 million tons annually, is consumed.

Previous to the erection of this plant the company had engaged in the resale of sulphuric acid and other heavy chemicals. The decision to build the new plant was dictated mainly by

View of new Sulphuric Acid Plant and Sulphur storage facilities.

the large tonnages of acid—about one-quarter of total usage—brought into this area, and the relatively high freight rates. It was also decided to manufacture some of the chemicals previously purchased from other companies.

The company purchased in June 1955 approximately $5\frac{1}{2}$ acres of unimproved industrial land in Newark Bay and has since then constructed dock facilities. The sulphuric acid plant which covers about 1/6th of the site is the first step in Dixon Chemical's $9 million expansion scheme. In addition to a research and development laboratory which is planned, $\$\frac{3}{4}$ million have been allocated for the construction of an aluminium sulphate plant in 1957.

Sulphuric Acid from Zinc Concentrates

During 1955, 1,112,052 short tons of by-product sulphuric acid (100% H_2SO_4) were produced at copper, zinc and lead plants in the United States and represented an increase of 26% over 1954. Production at zinc plants rose 28% to 792,936 tons while output at copper plants rose to 329,114 tons, an increase of 20% compared with the previous year's figures. The principal additions to by-product sulphuric acid capacity in 1955 were the first full year's operation of Bunker Hill Company's new by-product acid plant at Kellogg, Idaho, the completion of acid plants based on the use of sulphur recovered from zinc smelter gases by the Anaconda Company and the Eagle Picher Company. The Anaconda Company's new plant is of the contact type and has a daily capacity of 100 tons (100% H_2SO_4). Located at the zinc smelter at Anaconda, Montana, the gases, which contain about 6% SO_2, are obtained from the calcining in a FluoSolids roaster of zinc concentrates averaging 33-35% sulphur.

FRANCE

Anhydrite Plant to Close

The only plant of its type in France, the gypsum based sulphuric acid plant of *Direction des Poudres* of the French National Defence Ministry was closed early this year. Located at Miramas in the province of Boûches-du-Rhône, 20 miles north-west of Marseilles, the plant entered operations in 1930 but was partly destroyed during the war. Originally it embodied a kiln 60 metres long, 3.10 metres in diameter, with a daily capacity of 50-60 tons clinker and acid. Following reconstruction the plant operated from 1950-1953 and during that time acid production averaged about 70 metric tons per day.

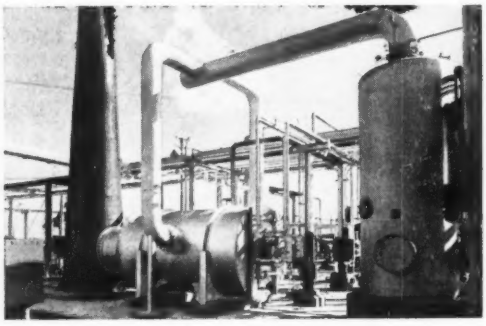
Due to the smallness of the operations and adverse raw materials supply facilities which occasioned the high cost of production, it is thought unlikely that the plant will resume operations.

Chemicals from Natural Gas

Plans are now under active preparation for the establishment of a chemical industry based on the natural gas supplies arising at Lacq. Challenged by the magnitude of the project, leading French chemical mining and financial interests represented by Office Nationale de l'Azote, Pechiney, St. Gobain and Pierrefitte-Kalaa-Djerda companies and the Banque de Paris et des Pays-Bas, have

combined to form the *Societé des Produits Chimiques d'Aquitaine*. Their backing ensures that the new company starts with adequate capital resources, technical know-how and existing kindred manufacturing, sales and distributing organisations which promise the fullest and most versatile use being made of natural gas.

Nevertheless, a precondition for the success of the Lacq project remains the physical utilization of the large potential volume of natural gas, on the full use of which also depends the size of the recovered sulphur output. It may be expected that a sizeable volume of high calorific gas may be used to upgrade producer gas into town gas of adequate thermal value.



Sulphur Recovery Unit at Lacq (constructed by Parsons and Heurtey).

Full use, however, is likely to depend on its reaching major industrial areas—Paris or even the North of France—which would necessitate the construction of long-distance pipelines in a densely-populated country entailing much greater difficulties than the longer lines in Canada or in the U.S.A.

The advantages of the largest possible gas off-take at, or near the source during the early stages of the project cannot be sufficiently emphasised and it is because of this that the plan for chemicals manufacture are of great importance. Already production plans for the manufacture of acetylene, methanol and ammonia are under active preparation and a major sulphuric acid plant, which is to form the basis of a wide range of inorganic chemical products is also planned. Its initial output of 100,000 tons per annum (100% H_2SO_4) will help to diversify the foreseen arising of synthetic nitrogen so that apart from ammonium sulphate manufacture high concentrate fertilizers such as di-ammonium phosphate and triple-superphosphate may also be produced.

The rate of progress of the Lacq project is exceeding expectations and it is now confidently anticipated that operations will start early in 1957 and that soon after will reach a level of gas disposal to employ fully the first gas cleaning and sulphur recovery plant which as earlier reported has a production capacity of 70,000 tons per annum sulphur.

GERMANY

New Sulphuric Acid Plant

The new contact sulphuric acid plant of *Chemische Werke Albert* at Wiesbaden, started operation in the summer of this year. With a capacity to produce 50 tons per day (100% H_2SO_4) the plant has a Dorr-Oliver FluoSolids roaster capable of treating daily 35 tons of pyrites. Utilizing pyrites from domestic and foreign sources, with a sulphur content of between 45-48%, the SO_2 is converted to sulphuric acid in a Petersen sulphuric acid unit.

Recovery of Sludge Acid

Chemische Werke Hüls A.G., the largest petrochemical company in West Germany, has recently installed at its refinery a plant to recover sulphuric acid used for cleaning petroleum products. Previously wasted, the sludge will now be heated to 1,000°C to form sulphur dioxide, carbon dioxide and water, after which the SO_2 will be cleaned and dried and converted to SO_3 in a Horden contact plant before absorption in dilute sulphuric acid.

The plant, which recovers about 95% of the available total, is capable of producing up to 15,000 tons per annum of high concentrated sulphuric acid.

EASTERN GERMANY

Sulphuric Acid from Anhydrite

The new Five-Year Plan in East Germany for realization in 1960 sets sulphuric acid production at 890,000 tons (100% H_2SO_4). This target represents an increase of 50% over 1955 production of 585,000 tons ; the principal addition to new capacity will be an anhydrite acid plant at Coswig.

Similar to the anhydrite acid plant at Wolfen, near Bitterfeld, which started on the

1st September 1956, and has an annual capacity of 140,000 tons (100% H_2SO_4), the Coswig plant will use raw material from Niedersachswerfen in the Harz. It will have a capacity of 180,000 tons per annum (100% H_2SO_4) and it is hoped that this plant will be in partial operation by 1959.

Another project due to be completed in 1957 entails the manufacture of sulphuric acid from lead smelter gases at Hüttenwerke Halsbrücke, near Freiberg, Saxony. Operating since January, 1956, a pilot plant has been producing at a monthly rate of 60 tons (100% H_2SO_4). When completed, the new by-product acid plant will contribute 4,500 tons annually towards East Germany's acid requirements.

SPAIN

Expansion of Sulphuric Acid Capacity—1955

Following the recent up-swing in the expansion of the Spanish economy, 1955 saw the completion of five sulphuric acid plants which raised total productive capacity of the industry to 1.06 million tons, an increase of 5½% compared with the preceding year. Actual acid production, however, rose by 9½% to 853,192 tons (100% H_2SO_4) and demand for sulphuric acid is now in excess of production. Not only are growing quantities required for the fertilizer industry and the expanding pulp and paper industry in the North, but also its use is more diversified than four years ago, in particular for the petroleum refining and synthetic detergent industries. The new sulphuric acid plants listed received planning permission during 1955. These plants are in addition to those approved in 1954 and the capacity of all projects now stands at 920,000 tons (100% H_2SO_4). An interesting new venture which is being considered by a German firm on behalf of a Spanish finance group is the production of large quantities of ammonium sulphate based on the use of gypsum deposits of Saragossa and the nearby lignite reserves of Utrillas.

Another German/Spanish project is under consideration by Cía Siderúrgica Nacional S.A. which entails the installation of a German-built plant for the manufacture of sulphuric acid from ferrous sulphate.

Company	*Location*	*Type*	*Capacity 100% H_2SO_4 metric tons*
Cia Espanola Minas Rio Tinto S.A. ...	Rio Tinto	Contact ...	52,920
Barrau S.A.	Mongat	Chamber ...	10,116
Productos Quimicos de Malgrat S.A. ...	Malgrat	Contact ...	41,000
F.E.F.A.S.A.	Mirando de Ebro ...	Contact ...	54,000
Unquinesa...	Axpe-Bilboa	Contact ...	54,000

Industries Associated and Dependent on Sulphur

World Ammonium Sulphate Supplies

Developments affecting ammonium sulphate supplies form an important part of two authoritative reports on world production and consumption of nitrogen, which were published early in December. They are the annual reports of *Messrs. Aikman (London) Ltd.* and the *British Sulphate of Ammonia Federation.* According to the latter, which specifies the production of the different nitrogen compounds for industrial and fertilizer use, output of ammonium sulphate in 1955/56 totalled 2.6 million tons N, 9% more than in the preceding year. This entailed the use of about 3¼ million tons sulphur in various forms representing about 23% of world sulphur consumption. It is significant that during the past three years world production of nitrogen expanded by nearly 40%, mainly on account of the greater proportionate rise in the production of urea, lime, ammonium nitrate types and other forms of nitrogen, whereas cyanamide, nitrate of lime and of soda show little change and output of ammonium sulphate has risen only 30%.

Although the two reports differ in details, both record an excess of production (Aikman, 8.18 million tons N; British Sulphate of Ammonia Federation, 8.61 million tons N) over industrial and fertilizer consumption (7.58 and 8.46 million tons respectively).

The Aikman report indicates that, in default of a change in current plans, serious over-production of nitrogen compounds would occur and excessive stocks would accumulate by the middle of 1958. Already production in the U.S.A. has been cut back and the low

prices of synthetic ($32 per ton) and by-product ($30 per ton) ammonium sulphate are a testimony of the abundance of supplies. The attractions of high concentration nitrogen compounds also mitigate against ammonium sulphate. It is estimated that during the next three years the probable rise in output of ammonium sulphate will necessitate the additional use of about 600,000 tons sulphur, of which up to one-quarter may be expected to be consumed in the form of anhydrite or gypsum.

CANADA

New " Alum " Production

The rapid expansion of pulp and paper manufacture in Western Canada has prompted Nichols Chemical Company to add aluminium sulphate to the range of products of its works at Barnet, B.C. Hitherto the entire aluminium sulphate requirements of Western Canada had to be imported either from the U.S.A. or from chemical works in Ontario.

The new plant, which was completed recently, will thus provide an important part of the rising demand in British Columbia and Alberta for this essential chemical. The sulphuric acid required in its manufacture will be met from the existing installation at Barnet, which are based on the use of pyrites.

UNITED STATES

Anaconda Ammonium Phosphate Project

The Anaconda Company is planning the erection of a plant, at a cost of about $1 million, for the production of ammonium phosphate fertilizer. An important development in the company's range of activities, it is intended to base the production of wet process phosphoric acid on phosphate rock from Anaconda's mines at Conda, Idaho, while anhydrous ammonia will be purchased from the U.S. Steel Corporation's new $18 million coal chemical plant now nearing completion at the Geneva works near Provo, Utah.

Due for completion this spring, and possibly to supply this project, is the Anaconda Company's sulphuric acid plant, which will raise the company's daily capacity from 250 tons to 450 tons (100% H_2SO_4). The plant, which is being built by Monsanto, will roast in a 22 foot FluoSolids roaster, pyrite concentrates obtained from the re-treatment of copper tailings.

SPAIN

Expansion of Fertilizer Industry

Pressure of the increasing demand for fertilizers, coupled with the Government desire to increase nitrogenous fertilizer production, has recently resulted in two companies seeking planning permission from the Institute Nacional de Industria for the erection of a complete fertilizer plant at Sevilla. The plant, to be operated by *Unión Española de Explosivos* and *Soc. Ibérica del Nitrógeno*, is expected to have an anuual capacity of 25,000 tons N, 30,000 tons P_2O_5, 25,000 tons K_2O and fertilizers to be produced will include superphosphate, potassium sulphate and urea.

WEST GERMANY

New Titanium Dioxide Plant

At a cost of DM 100 million *Farbenfabriken Bayer A.G.*, have under construction

Sulphuric Acid Tanks at Leverkusen.
Photo by courtesy of Farbentabriken Bayer A.G.

at Urdingen a plant for the production of titanium dioxide. Sulphuric acid requirements for this project will be supplied from existing installations which currently produce in excess

of ¾ million tons annually (100% H_2SO_4) wholly from domestic and imported pyrites.

It is anticipated that the plant will be producing titanium dioxide pigments early in 1958 and will be capable of meeting West Germany's demand for this product.

JORDAN

Superphosphate Project

Great efforts are being made by the Jordan Government to promote the installation of a 100,000 tons per annum superphosphate plant which would provide an important domestic outlet for the growing output of phosphate rock, all of which is at present exported mainly to Iron Curtain countries and Japan. By far the most important mineral product of the country, phosphate rock deposits extend from north of Amman, the capital, to Aquaba on the Red Sea; exploitation is centred on Rassifar, the largest mine 14 kms. north of Amman, with estimated resources of 32 million tons of 72-75% rock (B.P.L.) and Kal'at el Hasa, 130 km. south of the capital, where some 14 million tons of 62-74% rock (B.P.L.) are inferred. In the past five years production of phosphate rock has increased 20-fold to about ¼ million tons and is planned eventually to increase to 2 million tons annually. The production of superphosphate is to be based, initially, on imported U.S. sulphur and later on local resources. In default of supplies from native sulphur deposits, the use of sulphur recovered from natural gas in Iraq is a possibility and consideration is also being given to the use of gypsum for sulphuric acid manufacture. An interesting feature of Jordan phosphates is the relatively high uranium oxide content which is recoverable in conjunction with wet process phosphoric acid manufacture.

CHINA

Expansion of Fertilizer Output

Under the second five-year plan China proposes to achieve a five-fold increase in fertilizer production, and place at the disposal of agriculture 3 to 3½ million tons by 1962. Its realisation will be much helped by the exploitation of a large phosphate deposit at Kunming-Yunnan—where it is planned to erect a 600,000 tons per annum superphosphate plant.

China is self-sufficient as to sulphur, which is available both as brimstone and in pyrites. According to unconfirmed reports, substantial quantities of brimstone are being exported to chemical combines in Siberia.

Statistical Appendix

United States

		PRODUCTION		STOCKS		EXPORTS	IMPORTS
		Frasch	*Recovered*	*Frasch*	*Recovered*		
1953		5,155,342	337,099	3,022,486	107,344	1,241,536	
1954		5,515,543	357,400	3,228,020	109,066	1,647,011	1,104
1955		5,743,344	401,650	3,181,198	110,591	1,595,419	38,317
1956	January	531,330	40,900	3,216,150	121,066	114,610	12,150
	February	476,313	37,100	3,194,019	121,438	137,701	2,639
	March	485,963	38,100	3,204,568	118,913	94,425	24,796
	April	504,289	36,200	3,240,373	118,760	117,072	20,119
	May	543,217	38,500	3,276,638	113,377	131,049	10,025
	June	565,002	38,200	3,330,433	111,945	157,940	12,437
	July	621,130	43,400	3,493,942	115,246	136,048	15,036
	August	597,699	42,500	3,636,730	115,047	188,240	15,347
	September	524,370	42,000	3,680,784	117,759	138,784	28,440

Official Bureau of Mines Data (long tons of 2,240lbs.)

O.E.E.C. — 1955

	Native (x) and Recovered Sulphur	Sulphur in Pyrites	Other Forms	Total	Elemental Sulphur	Sulphur in Pyrites	Other Forms	Total
	PRODUCTION				*CONSUMPTION*			
	Thousand metric tons							
Austria ...	... —	—	77.5	77.5	25	29.2	75.5	129.7
B.L.E.U. ...	... 0.4	—	2.6	3	68.3	191.5	140.9	400.7
Denmark...	... —	—	1.6	1.6	1.1	59.7	7.8	68.6
France ...	... 2.9	131.2	30.5	164.6	195.8	392	90.5	678.3
Germany...	... 72	246	82	400	94	700	144	938
Greece ...	... 3.7	112.7	11.8	128.2	10.4	42.5	3.6	56.5
Ireland ...	... —	—	0.4	0.4	0.3	38.6	—	38.9
Italy ...	... 185	591.5	113.6	890.1	107.2	633	96.6	836.8
Netherlands	... 7	—	6.8	13.8	3.2	203.5	18.1	224.8
Norway ...	... 100.4	239.5	4.5	344.4	27.1	48.4	16.5	92
Portugal ...	... 15.7	308.5	—	324.2	(17.5)a	91.8	—	109.4
Sweden ...	... 28.9	193.5	31.7	254.1	66.6	241.2b	—	307.8
Switzerland	... —	—	1.3	1.3	52	27	0.2	79.2
Turkey ...	... 11.5	28	1.5	41	8.8	1.5	1	11.3
U.K. ...	... 46.6	0.9	417.3	464.8	382	223.4	468.5	1,073.9
Total	... 471.1	1,851.8	783.1	3,109	1,059.3	2,923.1	1,063.5	5,045.9

a—Apparent consumption.

b—1954 figure. Information for 1955 not yet available.

Italy

FUSED SULPHUR EXPORTS

metric tons

	*1954-1955**	*1955-56**
Czechoslovakia ...	2,288	4,389
France ...	2,900	40,295
Yugoslavia ...	979	2,773
Malta ...	1	—
Portugal ...	2,100	1,100
Algeria ...	860	9,960
Tunisia ...	1,030	11,450
Austria ...	—	4,360
Germany ...	—	—
Greece ...	—	900
Poland ...	—	650
Switzerland ...	—	8,730
Israel ...	—	5,000
U.S.S.R. ...	—	1,970
Total ...	10,158	91,577

* 31st July to 1st August.

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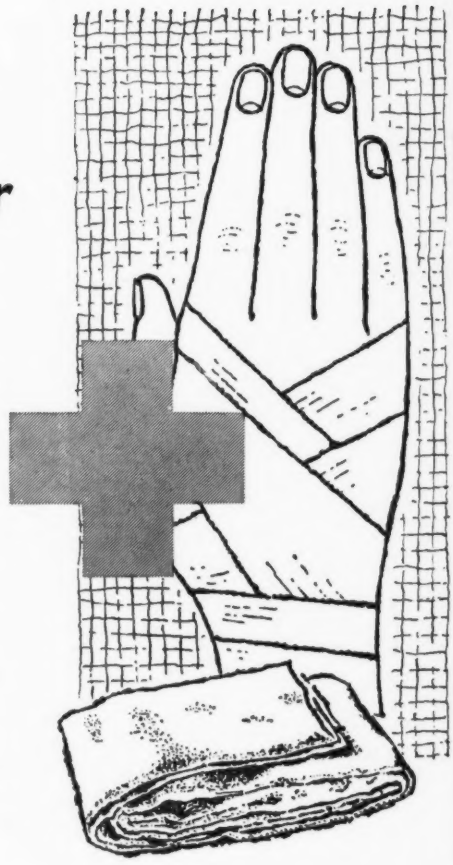

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